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Bailey, H. L., Dept. of Agriculture, Montpelier, Vt.
Baker, Arthur C., Bureau of Entomology, Washington, D. C
Baker, A. W., Ontario Agricultural College Guelph, Canada.
Baker, Howard, Box 1715, Shreveport, La.
Baker, Wm. A., Drawer 359, Monroe, Michigan.
Balduf, W. V., 610 Michigan Ave., Urbana, Ill.
Ball, E. D., Agr. Exp. Sta., Univ., Tucson, Ariz
Banks, C. S., Box 2314, Manila, P. I.
Barber, E. R., 1200 S. Broad St., New Orleans, La.
Barber, H. S., U. S. Natl. Museum, Washington, D. C.
Barnes, D. F., 712 Elizabeth St., Fresno, Calif.
Barnes, Olus L., U. S. Ent. Lab., Tempe, Ariz.
Bartlett, O. C., Box 1857, Phoenix, Arizona.
Bartley, H. N., 22 Elizabeth Street, So. Norwalk, Conn.
Basinger, A. J., Citrus Exp. Sta., Riverside, Calif.
†Batchelder, C. H., 15 Harding Ct., Melrose, Mass.
Beal, James A., Room 501, Lewis Bldg., Portland, Oregon.
Becker, G. G., Plant Quar. & Control Admin., Washington, D. C.
†Beckwith, Charles S., Cranberry Exp. Sta., Pemberton, N. J.
Bedford, Theodore, Welcome Res. Lab., Khartum, Sudan.
†Bentley, G. M., Knoxville, University of Tennessee.
Berger, E. W., Box 656, Gainesville, Fla.
Berly, J. A., Clemson College, S. C.
Beutenmuller, William, 85 Elm Street, Tenafly, N. J.
Bibby, F. F., Div. of Ent., College Station, Texas.
Bigger, J. H., 1114 S. Main St , Jacksonville, Ill.
Bilsing, S. W., College Station, Texas.
†Bishopp, F. C., Bur. of Ent., Washington, D. C.
Bissell, Theo. L., Experiment, Ga.
Blackman, M. W., Bureau of Ent., Washington, D. C.
Blanchard, R. A., 600 26th St., Sacramento, Calif.
Bliss, Chester I., 724 Earlham Drive, Whittier, Calif.
Bondy, Floyd F., Box 65, Florence, S. C.
†Bourne, Arthur I., Amherst, Mass.

†Members who attended 1932 meeting.

Boyce, Alfred M., Citrus Exp. Sta., Riverside, Calif.
Boyd, Mark F., Moingona, 615 Highland Ave., R. R. No. 2, Tallahassee, Fla.
Boyden, B. L., Indio, Calif.
Bradley, George H., Box 491, Orlando, Fla.
Brannon, C. H., State College, Raleigh, N. C.
Brannon, L. W., 128 Ohio Ave., Ingeside, Norfolk, Va.
Breakey, Edward P., Ohio Biol. Survey, O. S. Univ., Columbus, Ohio.
Brewer, Erle G., 615 Front St., Toledo, Ohio.
Brimley, C. S., Dept. of Agric., Raleigh, N. C.
Brittain, W. H., Macdonald College, St. Anne de Bellevue, Quebec, Canada.
†Britton, W. E., New Haven, Conn.
Broadbent, Bessie M., 724 Earlham Drive, Whittier, Calif.
Bromley, S. W., c/o Bartlett Tree Research Labs., Stamford, Conn.
Brown, Luther, Bureau of Ent., Albany, Georgia.
Brown, Raymond C., Bureau of Ent., Melrose Highlands, Mass.
Bruce, Wesley G., Dept. of Ent., K.S.A.C., Manhattan, Kansas.
Brues, C. T., Zool. Lab., Harvard Univ., Cambridge, Mass
Bruner, L., 3033 Deakin St., Berkeley, Calif.
Bryson, Harry R., K. S. A. C., Manhattan, Kansas.
†Bulger, J. W., Bureau of Ent., Washington, D. C.
†Burdette, R. C., Agric. Exp. Sta., New Brunswick, N. J.
†*Burgess, A. F., Greenfield, Mass.
Burke, H. E., 1551 Emerson St., Palo Alto, Calif.
Burrell, Robert W., 70 Groveland St., Abington, Mass.
Burrill, A. C., Missouri Resources Museum Com., Jefferson City, Mo.
Butler, Harold G., Bureau of Ent., 909 Crescent St., Harriman, Tenn.
Buys, John L., St. Lawrence Univ., Canton, N. Y.
Bynum, E. K., Box 366, Houma, La.

Caesar, Lawson, Ontario Agric. College, Guelph, Canada.
†Caffrey, Donald J., 615 Front St., Toledo, Ohio.
Cagle, L. R., Agric. Exp. Sta., Blacksburg, Va.
†Campbell, F. Leslie, 7710 Blair Rd., Takoma Park, Md.
Campbell, R. E., Box 297, Alhambra, Cal.
Carter, Walter, University of Hawaii, Honolulu, H. T.
Cartwright, Oscar L., Div. Ent., Exp. Sta., Clemson College, S. C.
Cartwright, Wm. B., 600 26th St., Sacramento, Calif.
Cassidy, T. P., Box 1910, Tucson, Arizona
Caudell, A. N., U. S. Natl. Museum, Washington, D. C.
Cecil, Rodney, Box A 3, Ventura, Calif.
Chamberlin, F. S., Box 239, Quincy, Fla.
Chamberlin, Joseph C., Box 1100, Twin Falls, Idaho.
Chamberlin, T. R., Forest Grove, Oregon.
Chamberlin, W. J., Route 3, Corvallis, Oregon.
†Chambers, E. L., State Ent. Office, State Capitol Annex, Madison, Wisconsin.
†Chandler, Stewart C., Route No. 5, Carbondale, Ill.
Chapman, P. J., Exp. Sta., Geneva, N. Y.

†Members who attended 1932 meeting.
*Life members.

Chapman, R. N., Univ. Hawaii, Honolulu, H. T
Childs, Leroy, Hood River, Oregon.
†Claassen, P. W., 102 Irving Place, Ithaca, N. Y.
Clark, Sherman Wood, Substation No. 15, Weslaco, Texas.
†Clausen, C. P., Bureau of Entomology, Washington, D. C.
Cleveland, C. R., 910 S. Michigan Ave., Chicago, Ill.
Cóckerell, T. D. A., 908 10th St., Boulder, Colo.
Cockerham, K. L., Box 205, Biloxi, Miss.
Colcord, Mabel, Bureau of Entomology, Washington, D. C.
Cole, Frank R., U. S. D. A., Lab., Whittier, Calif.
†Collins, C. W., Melrose Highlands, Mass.
Colman, Wallace, Box 241, Silver Spring, Md.
Compton, C. S., Floriculture Bldg., Urbana, Ill.
Cook, Mel T., Insular Exp. Sta., Rio Piedras, P R.
Cook, Wm. C., Box 488, Davis, Calif.
Cooley, Charles E., Box 994, Bellingham, Wash
Cooley, R. A., U. S. Public Health Service, Hamilton, Mont
Corkins, C. L., University of Wyoming, Laramie, Wyoming
†Cory, E. N., College Park, Md.
Cotton, E. C., R. 3, Elyria, Ohio.
Cotton, R. T , Bureau of Entomology, Washington, D. C
Craighead, F. C., Bureau of Entomology, Washington, D C
Crampton, G C., Mass. State College, Amherst, Mass.
Crawford, H. Gordon, Entomological Branch, Ottawa, Can.
Creel, C. W., Agric. Extension Division, Univ. of Nevada, Reno, Nevada.
Cressman, Albert W., Box 7 Station G., New Orleans, La.
Criddle, Norman, Treesbank, Manitoba, Canada.
Crossman, S. S., 20 Sanderson St., Greenfield, Mass
Crosby, C. R., Cornell University, Ithaca, N Y.
Crumb, S. E., Box 233, Puyallup, Wash.
Cushing, Emory C., P. O. Box 487, Menard, Texas.
†Cutright, C. R., Exp. Station, Wooster, Ohio.

Dampf, Alfons, Avenida, Insurgentes 171, Mexico, D. F.
Daniel, Derrill M., Exp. Sta., Geneva, N. Y.
Davidson, W. M., R. F. D. 1, Silver Spring, Md.
Davis, A. C., 7710 Blair Rd., Takoma Park, Maryland.
Davis, Edgar W., 601 McCormick Bldg., Salt Lake City, Utah.
Davis, E. G., U. S. Ent. Lab., Tempe, Arizona.
†Davis, J. J., Agric. Exp. Sta., Lafayette, Ind.
Dean, George A., K. S. A. C., Manhattan, Kansas.
Deay, Howard, School of Agriculture, Purdue Univ., Lafayette, Ind.
Decker, George C., Dept. of Zool. & Ent., Iowa State College, Ames, Iowa.
†DeLong, Dwight M., Ohio State Univ., Columbus, Ohio.
deOng, E. R., Mills Bldg., San Francisco, Calif.
Detwiler, J. D., 844 Hellmuth Ave., London, Ontario.
Dietrich, Henry, Roberts Hall, Ithaca, N. Y.
†Dietz, H. F., Ohio Agric. Exp. Sta., Wooster, Ohio.

†Members who attended 1932 meeting.

Ditman, L. P., Univ. of Maryland, College Park, Md.
Doane, R. W., Stanford University, Calif.
Dodds, C. T., 60 Avis Road, Berkeley, Calif.
†Dohanian, S. M., 42 Cedar St., W. Somerville, Mass.
Doucette, C. F., Box 566, Sumner, Wash.
Douglass, James R., Box 353, Estancia, New Mexico.
Dove, W. E., Box 324, Charleston, South Carolina.
Dowden, P. B., 1156 Main Street, Melrose Highlands, Mass.
Downes, W., Ent. Lab., Victoria, B. C.
Dozier, H. L., Chief Entomologist Service Technique, Port-au-Prince, Haiti.
Drake, Carl J., Iowa State College, Ames, Iowa.
†Driggers, B. F., Exp. Sta., New Brunswick, N. J.
Dudley, J. E., Jr., Exp. Station, Madison, Wisconsin.
Dunavan, David, Clemson College, South Carolina.
Dunham, W. E., Dept. Ent., O. S U., Columbus, Ohio.
Dunnam, E. W., Box 750, Bryan, Texas.
Dusham, E. H., College Heights, State College, Pa.
Dustan, Alan Gordon, Ent. Branch, Ottawa, Canada.

Ebeling, Walter, 301 E. Cypress St., Anaheim, Calif.
Eckert, J. E., Div. Ent. & Parasitology, College Agri.., Davis, Calif.
Eddy, C. O., Agric. Exp. Sta., Lexington, Kentucky
Ellington, George W., Silver Spring, Maryland
Elmore, J. C., Box 297, Alhambra, Calif.
Emery, W. T., 128 S. Minneapolis Ave., Wichita, Kansas.
English, Lester L., Spring Hill, Alabama.
Essig, E. O., Dept. of Ent., Univ. of Calif., Berkeley, Calif.
Evenden, James C., Coeur d' Alene, Idaho.
Ewing, H. E., U. S. Natl. Museum, Washington, D C
Ewing, K. P., Tallulah, La.
Eyer, J. R., Biol. Dept., State College, New Mexico.

Fackler, H. L., Knoxville, Tenn.
Farrar, Clayton L., U. S Bee Culture Field Station, Laramie, Wyoming.
Farrar, Milton D., State Ent. Bldg., Urbana, Ill.
Farrer, Edward R., South Lincoln, Mass.
Faxon, Richard, Box 991, San Juan, P. R.
†Felt, E. P., c/o Bartlett Research Labs., Stamford, Conn
Fenton, F. A., Station A., Box 67, El Paso, Texas.
Fernald, H. T., 707 E. Concord Ave., Orlando, Fla.
Ferris, G. F., Stanford Univ., Calif.
Ficht, George A., Dept. Ent., Purdue Univ. Exp. Sta., Lafayette, Ind.
Filinger, George A., Dept. Hort., K. S. A. C., Manhattan, Kans.
Filmer, Robert S., Rutgers Univ., New Brunswick, N. J.
†Fink, D. E., 7710 Blair Road, Takoma Park, Md.
Flanders, Stanley E., Citrus Exp. Station, Riverside, Calif.
Flebut, A. J., c/o Cal. Spray Chemical Co., 15 Shattuck Square, Berkeley, Calif.
†Fleming, Walter E., Box H, Moorestown, N. J.
Fletcher, Robert K., Box 152, Faculty Exchange, College Station, Texas.

†Members who attended 1932 meeting.

Fleury, Arthur C., c/o State Dept. of Agric., Sacramento, Calif.
†Flint, W. P., 1006 S. Orchard St., Urbana, Ill.
Fluke, Jr., C. L., University of Wisconsin, Madison, Wis.
Folsom, J. W., Tallulah, Louisiana.
Ford, Anson L., Extension Division, Brookings, S. D.
Ford, M. H., 503 Rio Grande National Life Bldg., Harlingen, Texas.
Fox, Henry, Box H, Moorestown, N. J.
†Fracker, Stanley B , 3716 Ingomar St., N. W., Washington, D. C
Frankenfeld, J. C., U. S. Ent. Lab., Tempe, Arizona.
Franklin, H. J., East Wareham, Mass.
Freeborn, Stanley B., University of California, Davis, Calif.
†Friend, Roger B., Agric. Exp. Station, New Haven, Conn.
Frison, T. H., Natural History Survey, Natural History Bldg., Urbana, Ill
†Frost, Stuart W., Research Lab., Arendtsville, Pa.
Fullaway, D. T., Dept. of Agric., Honolulu, H. T.
Fulton, B. B., N. C. State College, Raleigh, N. C.
Fulton, Robert A., Box 1100, Twin Falls, Idaho.

Grahm, Otis E., West Chester, Pa.
Gaines, Jr., J. C., Dept. of Ent., College Station, Texas
Gaines, R. C., Box 162, Tallulah, La.
†Gambrell, Foster L., Exp. Sta., Geneva, N. Y.
†Gardner, Theo. R., Jap. Beetle Lab., Moorestown, N. J
Garman, Harrison, 638 South Limestone St., Lexington, Ky.
†Garman, Philip, Exp. Station, New Haven, Conn.
Gentner, L. G., 1122 E. Main St., Medford, Oregon.
Gibson, Arthur, Entomological Branch, Ottawa, Canada
Gill, John B., Box 444, Albany, Georgia
Gillette, C. P., Fort Collins, Colorado.
Gilmore, John U., Box 346, Clarksville, Tenn.
†Ginsberg, Joseph M., Agric. Exp. Sta., New Brunswick, N. J.
†Glasgow, Hugh, Exp. Station, Geneva, N. Y.
Glasgow, R. D., State Entomologist, Albany, N. Y.
Glenn, P. A., c/o State Ent., Urbana, Ill.
Glover, Leon Conrad, Theta U. House, Durham N. H.
Goodwin, James C., Gainesville, Fla.
Goodwin, W. H., Box 5, North Lima, Ohio.
Gould, George E., Agric. Exp Sta., Lafayette, Indiana.
†Graf, J. E., Bureau of Entomology, Washington, D. C.
Graham, Samuel A., School of Forestry & Conservation, Univ. of Michigan, Ann Arbor, Michigan.
Granovsky, Alexander A., Div. of Ent., Univ. Farm, St. Paul, Minn.
Gray, George P., 683 Chamber of Commerce Bldg., Los Angeles, Calif.
Gray, H. E., 410 Commercial Bldg., Winnipeg, Manitoba, Canada.
Grimes, D. W., Durant, Mississippi.
Griswold, Grace H., Dept. of Ent., Cornell Univ., Ithaca, N. Y.
Grossman, E. F., 546 W. 113th St., New York.
Gui, Harry L., Agric. Exp. Station, Wooster, Ohio.

†Members who attended 1932 meeting.

Guyton, Fay E., 110 Miller Ave., Auburn, Ala.
†Guyton, Thomas L., Bureau of Plant Industry, Harrisburg, Pa.

Haack, T. T., 32 Brevoort Rd., Columbus, Ohio.
Haber, V. R., Zool. Dept., Penn. State College, State College, Pa.
†Hadley, C. H., Box H., Moorestown, N. J.
Haegele, Rowland W., Parma, Idaho.
Haeussler, Gilbert J., P. O. Box 47, Yokohama, Japan.
Hagan, H. R., c/o Mr. Wm. Lutjeharms, Alma, Nebraska.
Haley, W. E., 8203 Oak Street, Sugar Exp. Station, New Orleans, La.
Hall, M. C., Bur. Animal Industry, Div. Zool., Washington, D. C.
Hall, Ralph C., Forest Exp. Sta. O. S. U., Columbus, Ohio.
†Hallock, Harold C., Westbury, Long Island, N. Y.
Hambleton, James I., 423 Dorset Ave., Chevy Chase, Washington, D. C.
†Hamilton, C. C., Dept. Ent., Rutgers College, New Brunswick, N. J.
Hamlin, J. C., 473 Tonith Ave., Salt Lake City, Utah.
Hamner, Arthur L., A. & M. College, Miss.
Hargreaves, E., Lands and Forests Dept., Freetown, Sierra Leone, W. Africa.
Harman, S. W., Exp. Station, Geneva, N. Y.
†*Harned, R. W., Div. of Cotton Insects, Bur. of Ent., Washington, D. C.
Harris, Halbert M., Zool. Dept. Iowa State Coll., Ames, Iowa.
†Hartzell, Albert, Boyce Thompson Inst., 1086 No. Broadway, Yonkers, N. Y.
Hartzell, F. Z., N. Y. Exp. Station, Geneva, N. Y.
Haseman, Leonard, Univ. of Mo., Columbia, Mo
†Hawley, I. M., Box H, Jap. Beetle Lab., Moorestown, N. J.
Hayes, W. P., Dept. Ent.,, Univ. of Ill , Urbana, Ill.
†Headlee, T. J., New Brunswick, N. J.
Henderson, Chas. F., 222 6th Ave., East, Twin Falls, Idaho.
Henderson, W. W., Agric. Exp. Station, Logan, Utah.
Herbert, F. B., Los Gatos, Cal.
Herms, Wm. B., Univ. of Cal., Berkeley, Calif.
Herr, Edgar Allen, Agric. Exp. Sta., Wooster, Ohio.
†Herrick, Glen W., Ithaca, N. Y.
Hervey, G. E. R., Exp. Station, Geneva, N. Y.
Hester, J. G., Box 597, Agricultural College, Miss.
High, Marvin M., Box 989, Gulfport, Miss.
Hill, C. C., 624 W. Louther St., Carlisle, Pa.
Hinds, W. E., Dept. of Ent., La. State Univ., Baton Rouge, La.
Hinman, Frank G., 140 N. 25th St., Corvallis, Oregon.
Hobbs, Edward, Box 798, San Antonio, Texas.
†Hodgkiss, H. E., Old Exp. Station Bldg., State College, Pa.
Hodgson, B. E., 10 Court St., Arlington, Mass.
Hoerner, John L., Agric. Exp. Station, Ft. Collins, Colo.
Hoffman, W. A., School of Tropical Medicine, San Juan, P. R.
Hoffmann, W. E., Lignan University, Canton, China.
†Holloway, Jas. K., Box H, Moorestown, N. J.
Holloway, T. E., 8203 Oak Street, New Orleans, La.

†Members who attended 1932 meeting.
*Life members.

Hood, C E., Melrose Highlands, Mass.
Hooker, W. A., States Relation Service, U. S. D. A., Washington, D. C.
†Horsfall, J. L., 535 Fifth Ave., c/o Amer. Cyanamid Sales Co., New York, N. Y.
Horton, J. R., 128 So. Minneapolis Ave., Wichita, Kansas.
Hottes, Frederick C., 707 N. 7th St., Grand Junction, Colo.
†Hough, W. S., 523 Fairmount Ave., Winchester, Va.
Houghton, C. O., Newark, Del.
†Houser, J. S., Agric. Exp. Station, Wooster, Ohio.
Howard, L. O., Washington, D. C.
†Howard, N. F., 151 W. Eleventh Ave., Columbus, Ohio.
Howell, Peter A., c/o U. S. D. A., Worden St., Springfield, Ohio.
Huber, L. L., Wooster, Ohio Exp. Station, Ohio.
Huckett, H. C., R. F. D., Calverton, Long Island, N. Y
†Hungerford, H. B., Univ. of Kansas, Lawrence, Kansas
Hunter, S. J., Univ. of Kansas, Lawrence, Kansas
Hutson, John C., Royal Botanic Gardens, Peradeniya, Ceylon
†Hutson, Ray, Ent. Dept. State College, East Lansing, Mich
Hyslop, J. A., Bur. of Entomology, Washington, D. C

Illingworth, J. F., Bishop Museum, Honolulu, H. T.
Ingram, J. W., Houma, La.
Isely, Dwight, 3 N. Duncan St , Fayetteville, Arkansas

Jacobsen, W. C., 1341 43rd Street, Sacramento, Calif.
Jaenicke, Alex. J., U. S. Forest Service, Portland, Oregon.
Jaynes, Harold A., c/o W. R Grace & Co., Casilla Correo 307, Trujillo, Peru.
Jewett, Howard H., Exp. Sta., Lexington, Kentucky.
Johannsen, O. A., Box 48, Coll. Agric., Ithaca, N. Y.
†Johnson, J. Peter, Exp. Sta., New Haven, Conn.
Johnston, H. Bennett, Wellcome Laboratories, Khartoum, Sudan.
Johnston, H. G., A. & M. College of Texas, College Station, Texas.
Jones, C. R., Fort Collins, Colorado.
†Jones, Merlin P., Bur. of Ent., Washington, D. C.
Jones, P. R., 8742 Clifton Way, Beverly Hills, Calif.
Jones, T. H., Melrose Highlands, Mass.

Keen, F. P., 501 Lewis Bldg., Portland, Oregon.
Keenan, W. N., Entomological Branch, Ottawa, Canada.
Kellogg, C. R., Mass. State College, Amherst, Mass.
Kellogg, V. L., Natl. Research Council, 21 & B Sts., Washington, D. C.
Kelly, E. G., Extension Dept. K. S. A. C., Manhattan, Kansas.
Kelsheimer, Eugene G., Oak Harbor, Ohio.
Kennedy, C. H., O. S. U., Columbus, Ohio.
Kincaid, Trevor, Univ. Washington, Seattle, Washington.
†King, J. L., Box H, Moorestown, N. J.
King, K. M., Ent. Lab., Saskatoon, Saskatchewan, Canada.
King, W. V., Bur. of Science, Manila, P. I.
Kinsey, A. C., Ind. Univ., Bloomington, Ind.

†Members who attended 1932 meeting.

Kirk, H. B., 1902 North St., Harrisburg, Pa.
Kislanko, J. P., Wiggins, Mississippi.
†Kisliuk, Jr., Max, 134 S. 2nd Street, Philadelphia, Pa.
Knight, H. H., Dept. of Zool. & Ent., Iowa State College, Ames, Iowa.
Knowlton, George F., Utah Exp. Sta., Logan, Utah.
Knull, Josef N., Forest Research Inst., Mont Alto, Pa.

Laake, E. W., Box 208, Dallas, Texas.
Lammiman, John F., 201 Agr. Hall, U. of Cal., Berkeley, Calif.
Lane, Merton C., Box 616, Walla Walla, Wash.
†Langford, George S. U. of Md., College Park, Maryland.
Langston, James M., A & M. College, Miss.
†Larrimer, W H., Bur. Ent., Washington, D. C.
Larson, A. O., 337 N 11th Street, Corvallis, Oregon.
Lathrop, Frank H., 724 Earlham Drive, Whittier Calif.
Latta, Randall, Box 566, Sumner, Washington.
Lauderdale, J. L. E Box 368, Yuma, Arizona.
Lawson, Paul B., 635 Maine Street, Lawrence, Kansas.
Leiby, R. W., c/o State Ent Raleigh, N. C.
†Leonard, M. D., Amherst Apartments, Orlando, Fla.
Lewis, Harold C., Cal. Fruit Growers Exchange, Los Angeles, Calif.
Lipp, J W , 8316 Cadwalader Rd., Elkins Park, Pa.
List, G M , Fort Collins, Colo.
Little, V. A., College Station, Box 225, Texas
Lockwood, Stewart, Sacramento, Calif.
†Loftin, U. C., Bur. of Entomology, Washington, D. C
Luginbill, Philip, Box 359, Monroe, Mich.
†Lyle, Clay, A. & M , College, Miss.

MacAloney, Harvey J., 335 Prospect St., New Haven, Conn
Mackie, D. B., Dept. Agr., Sacramento, Cal.
†MacLeod, Guy F., Bailey Hall, Cornell Univ., Ithaca, N. Y.
Maheux, George, Dept. Agr., Quebec, Canada.
Mail, G. A., Dept. Ent. Mont. Expt. Sta., Bozeman, Mont.
†Manter, Jerauld A., State College, Storrs, Conn.
†Marcovitch, Simon, Univ. Farm, Knoxville, Tenn.
Marshall, G. Edward, Lafayette, Indiana.
Martin, Chas. H., Box 313, Sumner, Wash.
†Marvin, Geo. E., 423 Dorset Ave., Chevy Chase, Washington, D. C.
†*Marlatt, C. L., Bur. Ent., Washington, D. C
Mason, A. C., Box 340, Honolulu, H. T.
Matheson, Robert, Cornell Univ., Ithaca, N. Y.
Mathewson, A. A., Box 1077, San Antonio, Texas.
Maxson, Asa C., Longmont, Colo.
McAlister, L. C., Jr., Cherryfield, Me.
McBride, O. C., Box 340, Honolulu, H. T.
McClendon, Samuel E., 212 S. Hansell St., Thomasville, Ga.

†Members who attended 1932 meeting.
*Life members.

McConnell, H. S., College Park, Md.
McDaniel, Eugenia, State College, East Lansing, Mich.
McDonough, F. L., 50 Union Sq., N. Y. C., c/o Ansbacher Siegle Corp.
†McIndoo, N. E., 7225 Blair Rd., Takoma Park, Md.
McIntyre, H. L., Conservation Dept., Albany, N. Y.
McKinney, K. B., Box 352, Tempe, Ariz.
McLaine, Leonard S., Ent. Branch, Ottawa, Canada.
McLean, R. R., County Bldg., San Diego, Calif.
†Melander, A. L., Bio. Dept. College City of N. Y., N. Y. C.
Merrill, George B., Agl. Expt. Sta., Gainesville, Fla.
Merrill, Joseph H., Raynham Center, Mass
Metcalf, C. L, Univ. of Ill., Urbana, Ill
Metcalf, Z. P., West Raleigh, N. C.
†Metzger, Frederick W., Box H, Moorestown, N. J
Mickel, Clarence E., Dept. Ent., Univ Farm, St. Paul, Minn.
Millen, F. E., Guelph, Canada.
Miller, D. F., Dept. Ent., O. S. U., Columbus, Ohio.
Miller, Ralph L., Box 491, Orlando, Fla.
Milum, Vern G., 104 Vivarium Bldg., Champaign, Ill
Mitchell, Theo. B., Dept. Zool. & Ent., Raleigh, N. C.
Mitchener, A. V., Man. Agl. College, Winnipeg, Manitoba, Canada
Montgomery, J. H., State Plant Board, Gainesville, Fla.
Moore, William, c/o Amer. Cyanamid Co., Azuza, Calif.
Moreland, R. W., Bryan, Texas.
Morgan, H. A., Univ. of Tenn., Knoxville, Tenn.
Morrill, A. W., 1505 Winchester Ave., Glendale, Calif.
Morrison, Harold, Bur. Ent., Washington, D. C.
Morse, Albert P., Wellesley, Mass.
Mosher, Edna, Adelphi College, Garden City, N Y.
Mote, Don C., Agr. College, Corvallis, Ore.
Moulton, Dudley, Dir. of Agl., Sacramento, Calif
Moznette, G. F., Box 482, Albany, Ga.
Muesebeck, C. F. W., U. S. Nat. Museum, Washington, D. C.
Munro, J. A., State College, Fargo, N. D

Neiswander, Claud R., c/o Ohio Expt. Sta., Wooster, Ohio
Neiswander, Ralph B., Agr. Expt. Sta., Wooster, Ohio.
Nelson, J. A., Gambier, Ohio.
Ness, Henry, 821 Kellogg St., Ames, Iowa.
Neuls, J. D., 509 Acacia Ave., Whittier, Calif.
Newcomer, E. J., Box 243, Yakima, Wash.
Newell, Wilmon, Gainesville, Fla.
Nichol, A. A., Agri. Exp. Sta., Tucson, Ariz.
Nickels, C. B., Box 209, Brownwood, Texas.
Noble, Willis B., Box 495, W. Lafayette, Indiana.
Nolan, Willis J., 507 Cumberland Ave., Chevy Chase, Washington, D. C.

Oertel, E., Baton Rouge, Bee Culture Field Sta., La.

†Members who attended 1932 meeting.

†O'Kane, W. C., Durham, N. H.
†Osborn, Herbert, O. S. U., Columbus, Ohio.
†Osborn, Herbert T., c/o Rockefeller Inst., Princeton, N. J.
Osburn, Max R., Box H., Moorestown, N. J.
†Osburn, Raymond C., O. S. U., Columbus, Ohio.
Osgood, W. A., N. H. College, Durham, N. H
Owen, W. H., Jr., Box 197, Presidio, Tex.
Ozburn, Reginald H. Dept. Ent., Guelph, Ontario, Canada.

Packard, C. M., Box 495, Lafayette, Ind
Paddock, F. B., 535 Hayward Ave., Ames, Iowa.
Painter, H. R., Box 495, Lafayette, Ind
Painter, Reginald H., K. S. A. C., Dept. Ent., Manhattan, Kans.
Park, O. W., Science Bldg., Ames, Iowa.
Parker, H. L., European Parasite Lab., Ave. Godillot, Hyeres, Var, France.
Parker, J. B., 1217 Lawrence St., N. E., Washington, D. C.
†Parker, John R., Bozeman, Mont.
Parker, Ralph L., K. S. A. C., Manhattan, Kans.
Parker, R. R., U. S. P. H. S., Hamilton, Mont.
Parker, Wm. B., 15 Shattuck Sq., Berkeley, Calif.
Parks, H. B., Route 1, Box 368, San Antonio, Tex.
Parks, T. H., Dept. Ent. & Zool., O. S. U., Columbus, O.
Parman, D. C., Box 509, Uvalde, Texas.
†Parrott, P. J., Agl. Expt. Sta., Geneva, N. Y.
†*Patch, Edith M., Orono, Me
Patch, L. H., Box 976, Sandusky, Ohio.
†Peairs, L. M., U. of W. Va., Morgantown, W. Va.
†Peirson, Henry B., Dept. Forestry, State House, Augusta, Me.
Pellett, F. C., Hamilton, Ill.
Pemberton, C. E., Expt. Sta., H. S. P. A., Honolulu, H. T.
Penny, D. D., Watsonville, Calif.
Pepper, J. Oscar, 603 E. King St., Chambersburg, Pa.
Peters, Harold S., Bur. of Ent., Washington, D. C.
†Peterson, Alvah, O. S. U. Zool. Bldg., Columbus, Ohio.
Pettit, R. H., E. Lansing, Mich.
†Phillips, E. F., Dept. Ent., Cornell Univ., Ithaca, N. Y.
Phillips, W. J., Box 592, Charlottesville, Va.
Phipps, C. R., Expt. Sta., Orono, Me.
†Pierce, W. D., Acad. Nat. Science, Philadelphia, Pa.
Plank, H. K., c/o State Dept. of Agri., Sacramento, Calif
Polivka, Joseph B., Oak Harbor, Ohio.
Poos, F. W., Jr., c/o Arlington Farms, Rosslyn, Va.
†Porter, B. A., B. of E., Washington, D. C.
Potts, S. F., Melrose Highlands, Mass.
†Price, W. A., Agr. Expt. Sta., Lexington, Ky.

Quaintance, A. L., Washington, D. C.
Quayle, H. J., U. of Cal., Riverside, Calif.

†Members who attended 1932 meeting. *Life members.

Rea, George H., Reynoldsville, Pa.
Readeo, Philip A., Univ. Kans., Lawrence, Kans
Reed, W. D., 200 Bland Rd., Richmond, Va.
Reese, Charles A., Dept. of Agr., Columbus, Ohio.
Reeves, Geo. I., Room 403, Federal Bldg , Salt Lake City, Utah
†Regan, W. S., Moorestown, N. J.
Reid, Wm. J. Jr., U. S. Bur. Ent., Chadbourn, N. C
Reinhard, H. J., Exp. Sta., College Station, Texas.
†Ressler, I. L., c/o Roessler Hasslacher Chem. Co., Niagara Falls, N. Y.
†Richardson, C. H., Iowa State College, Ames, Iowa.
†Richardson, Henry H., Bur. Ent., Washington, D. C.
†Richmond, Edward A., 39 Newbury St , Brockton, Mass
Richmond, Roy G., Agr. College, Ft. Collins, Colo.
Riley, Harland Keifer, Purdue U. Exp. Sta., W. Lafayette, Ind
Riley, W. A., Univ Farm, St. Paul, Minn.
†Roark, R. C., U. S. Bur. Chem. & Soils, Washington, D C.
Roberts, R. A., Box 509, Uvalde, Texas.
Robinson, J. M., Box 247, Expt. Sta., Auburn, Ala
Robinson, R. H., Science Hall, Corvallis, Ore
Robinson, Wm., 126 Phila. Ave., Takoma Park, Md.
Rockwood, L P., Bur. Ent., Forest Grove, Ore
Rohwer, S. A., Bur. Ent., Washington, D. C.
Rosewall, O. W., La. State U., Baton Rouge, La
Ross, Wm. A., Vineland Sta., Ontario
Rude, C. S., Tlahualilo, Durango, Mexico.
Ruggles, A. G., Univ. Farm, St. Paul, Minn
Rumsey, W. E., Morgantown, W. Va.
Runner, G. A., Ent. Lab., Sandusky, Ohio
Ryan, Harold J., 524 N. Spring St., Los Angeles, Calif.

Safro, V. I., c/o Kay Labs. Inc., 180 Madison Ave., N. Y.
Salman, K. A., 341 Gianini Hall, U. Cal., Berkeley, Calif.
†Sanders, G. E., 419 Fourth Ave., N. Y. C., c o Bowker Chemical Co
†Sanders, J. G., c/o Sun Oil Co., Philadelphia, Pa.
†Sanders, P. D., Bur. Ent., Washington, D. C.
Sanderson, E. D., Cornell Univ., Ithaca, N. Y.
Sanford, H. L., Bur. of Plant Quarantine, Washington, D. C.
Sasscer, E. R., P. Q. C. A., Washington, D. C.
†Satterthwait, A. F., 527 Ivanhoe Pl., Webster Grove, Mo.
Sazama, Robert F., Box 167, U. S. Ent. Lab , Vincennes, Ind.
†Scammell, H. B., Toms River, N. J.
Schaffner, J. V. Jr., Melrose Highlands, Mass.
†Schlossberg, Morris, 615 Front St., Toledo, Ohio, c/o U. S. D. A.
†Schoene, W. J., Agl. Expt. Sta., Blacksburg, Va.
Schweiss, George G., State Quarantine Office, Reno, Nev.
Scullen, H. A., Corvallis, Ore.
Seamans, H. L., Ent. Lab. Lethbridge, Alberta, Canada.
Searls, E. M., 1532 Univ. Avenue, Madison, Wisc.

†Members who attended 1932 meeting.

Sechrist, Edw. L., Bee Culture Field Sta., Davis, Calif.
Severin, Harry C., Brookings, S. D
Severin, H. H. P., Coll. Agr. U. Cal., Berkeley, Calif.
Shafer, G. D., 321 Melville Ave., Palo Alto, Cal.
Shelford, V. E., Vivarium Bldg., Wright & Healy St., Champaign, Ill.
Shepard, Harold H., Univ. Farm, St. Paul, Minn.
Sheppard, R. W., P. O. Box 35, Niagara Falls, Ont., Canada.
Sherman, Franklin, Div. Ent. Zool., Clemson College, S. C.
Sherman, III, Franklin, Dept. Ent., M. A. C., East Lansing, Mich.
Shirck, F. H., Box 237, Parma, Idaho.
Shotwell, Robert L., 801 6th Ave. So., Bozeman, Mont.
Shull, W. E., U. of Idaho, Moscow, Idaho.
†Siegler, E. H., Bur. Ent., Washington, D. C.
Simanton, F. L., Drawer 359, Monroe, Mich.
Simmons, Perez, Dried Fruit Insect Lab., 712 Eliz. St., Fresno, Calif.
Sleesman, J. P., O. Agrl. Exp. Sta., Wooster, Ohio.
Smith, Charles E., Expt Sta , Baton Rouge, La.
Smith, Chas. M., 124 Allison St., N. W., Washington, D. C
†Smith, Floyd F., Bur. Ent , Washington, D. C.
Smith, Herbert D., LeMont Fenouillet, Hyeres, Var. France.
Smith, H. S., Citrus Expt. Sta., Riverside, Cal.
Smith, Leslie M., U. C , Deciduous Fruit Sta., San Jose, Calif.
Smith, Loren B., Dir. Ext. Pa. State College, State College, Pa.
Smith, Marion R., State Plant Bd., A. & M. College, Miss.
Smith, Roger C., Agr. College, Manhattan, Kans.
Smith, R. H., Citrus Expt. Sta., Riverside, Calif.
Smulyan, Marcus T., Melrose Highlands, Mass.
*Smyth, E. Graywood, Hacienda Cartavio, Salaverry, Peru.
Snapp, O I., Bur. Ent., Fort Valley, Ga.
Snow, S. J., Box 670, Fallon, Nevada.
Snyder, T. E., Washington, D. C., c o Bur. of Ent.
Sorenson, Chas. J., Expt. Sta., Logan, Utah.
Spencer, Geo. J., Dept. Zool. U. of B. C., Vancouver, B. C.
Spencer, Herbert, Box 482, Albany, Ga.
†Spruijt, F. Johannes, Box 786, Babylon, L. I., N. Y.
Stafford, E. W., Agri. College, Miss.
Stahl, C. F , Box 549, Sanford, Fla.
Stear, Jacob R., Koppers Expt. Farm, Ligonier, Pa.
†Stearns, Louis A., U. of Del., Newark, Del.
Steiner, L. F., Cornelia, Ga.
†Stene, A. E., Kingston, R. I.
St. George, R. A., Ent. Lab., E. Falls Church, Va.
Stickney, Fenner S., 724 Earlham Drive, Whittier, Calif.
Stirrett, Geo. M., Ent. Lab., Chatham, Ontario.
†Stockwell, C. W., 22 Elizabeth St., S. Norwalk, Conn.
Stone, Wm. E., Calzada Tacuba, 153 Colonia Anahuae, Mex.
Strand, A. L., Dept. Ent., State College, Bozeman, Mont.

†Members who attended 1932 meeting.
*Life members.

Strickland, E. H., U. of Alberta, Edmonton, Alberta, Canada.
Strong, Lee A., P. Q. C. A., Washington, D. C.
Struble, Geo. R., 341 Giannini Hall, Berkeley, Calif.
Sullivan, Knowls C., Plant Div. State Bd. Agr., Jefferson City, Mo.
Summers, John N., Greenfield, Mass.
Swain, A. F., Box 428, El Monte, Calif.
†Swaine, J M., Ottawa, Canada.
†Sweetman, Harvey L., M. S. C., Amherst, Mass
Swenk, M. H., 1410 No. 37th St., Lincoln, Neb.
Swezey, O. H., Sugar Planters Expt. Sta., Honolulu, H. T.
Swingle, Homer S., Box 247, Auburn, Ala
Symons, T. B., College Park, Md

Tanquary, M. C., Univ. Farm, St. Paul, Minn.
Taylor, R. L., Dept. Bio., College Wm & Mary, Williamsburg, Va
Tenhet, Joseph N., Fairfax, S C
†Thomas, C. A., Kennett Square, Pa.
Thomas, F. L., State Ent., College Station, Tex.
Thomas, W. A., Chadbourne, N. C.
Thompson, B. G., 303 Agr. Hall, Corvallis, Ore.
Timberlake, Philip H., Citrus Expt. Sta., Riverside, Calif.
Tissot, Archie N., Expt. Sta., Gainesville, Fla.
Titus, E. G., 1080 S. 5th Ave., Salt Lake City, Utah.
Todd, Frank E., Bee Culture Field Sta., Davis, Calif.
Todd, J. N., Box 1625, Riverside Sta., Miami, Fla
Trimble, F. M., Cumberland Co., Camp Hill, Pa.
Troop, James, Lafayette, Ind.
Turner, Neely, Agr. Expt. Sta., New Haven, Conn.
Turner, W. F., U. S. Peach Disease Lab., Fort Valley, Ga.

†Underhill, G. W., Rt. 4, Box 101A, Richmond, Va

†Vance, Arlo M., 10 Court St., Arlington, Mass.
VanDine, D. L., Leesville, La.
Van Duzee, E. P., Acad. Sc., G. G Park, San Francisco, Calif
Van Dyke, Edwin C., U. of Cal., Berkeley, Calif.
†Van Leeuwen, E. R., Box H., Moorestown, N. J
Vansell, Geo. H., Univ. Farm, Branch Coll. of Agri., Davis, Calif.
Van Zwalwenburg, R. H., H. S. P A., Expt. Sta., Honolulu, H. T.
Vickery, R. A., Box 884, San Antonio, Tex.
Vorhies, Chas. T., Univ. Sta., Tucson, Ariz

†Wade, Joe S., Bur. Ent., Washington, D. C
†Wadley, Francis M., Insect Pest Survey, Bur. Ent., Washington, D. C.
†Wakeland, Claude, Moscow, Idaho.
Walden, B. H., Expt. Sta., New Haven, Conn.
Walkden, H. H., 128 S. Minneapolis Ave., Wichita, Kans.
†Walker, Harry G., Truck Expt. Sta., Norfolk, Va.

†Members who attended 1932 meeting.

Wall, R. E., Bozeman, Mont.
Wallace, F. N., State Ent., Indianapolis, Ind
Walter, E. V., U S. Ent. Lab., San Antonio, Tex.
Walton, Wm. R., B. of E., Washington, D. C.
Watson, J. R., Agr. Expt. Sta., Gainesville, Fla.
Watson, S. A., 321 S. Washington Ave., Whittier, Calif.
Webb, J. L., Bur. Ent., Washington, D. C.
Webber, R. T., Melrose Highlands, Mass.
Webster, R. L., Dept. Zool., State Coll., Pullman, Wash.
†Weed, Alfred, c/o John Powell & Co., 114 E. 32nd St., N. Y. C
Wehrle, L. P , 117 Olive Rd., Tucson, Ariz
†Weigel, C. A., Bur. Ent., Washington, D. C.
†Weiss, Harry B., 19 N. 7th Ave., Highland Park, New Brunswick, N. J.
Weldon, G. P., 420 East D. St., Ontario, Calif.
Wellhouse, Walter, Dept. Ent. Zool., I. A. C., Ames, Iowa.
Wells, Roscoe W., 1162 E. Main St., Galesburg, Ill.
Wheeler, W. M., Mus. of Comp Zool., Cambridge, Mass.
†Whitcomb, W. D., 82 Plympton St., Waltham, Mass.
Whitehead, F. E., Dept. Ent., Okla. A. & M. College, Stillwater, Okla.
Wilcox, Joseph. Box 233, Puyallup, Wash
Wildemuth, V. L., Tempe, Ariz.
Willard, Harold F., Box 340, Honolulu, H. T.
Williams, C. B., Chief Ent., Rothamsted Exp. Sta., Harpenden, England.
Wilson, C. C., 600 26th St., Sacramento, Calif.
Wilson, H. F., 1532 Univ. Ave., Madison, Wisc.
Winter, James D., Univ. Farm, St. Paul, Minn.
Woglum, R. S., Cal. Fruit Growers Exch., Los Angeles, Calif
*Wolcott, G. N., Insular Expt. Sta., Rio Piedras, P. R.
Wood, W. B., P. Q. C. A., Washington, D. C.
Worthley, Harlan N., Old Expt. Sta. Bldg., State College, Pa
†Worthley, L. H., 22 Elizabeth St , S. Norwalk, Conn.
Wymore, Floyd H., Univ. Farm, Davis, Calif

Yeomans, Manning S., 332 State Capitol, Atlanta, Ga.
Yetter, Wm. P., Jr., Box 67, Cornelia, Ga.
Yothers, M. A., Box 1403, Wanatchee, Wash.
Yothers, W. W., Box 491, Orlando, Fla.
Young, Martin T., Tallulah, La.
Yuasa, Hachiro, Inst. of Ent., Kyoto Imperial Univ., Kyote, Japan.

†Zappe, Max P., Exp. Sta., New Haven, Conn.
Zetek, James, Drawer Z., Balboa, Canal Zone, Panama.
Total number of active members, 650.

ASSOCIATE MEMBERS

Aamodt, T. L., Univ. Farm, St. Paul, Minn.
Adams, J. Alfred, State College, Ames, Iowa.

*Life members.
†Members who attended 1932 meeting.

Allen, Thos. C., Dept. of Ent., Univ. Wis., Madison, Wis.
Amis, Albert H., Apartado 36, Los Mochis, Sinaloa, Mex.
†Anderson, L. D., Truck Exp. Sta., Norfolk, Va.
Anthony M. V., R. F. D. 4, Louisville, Ohio.
Arbuthnot, Kenneth D., Drawer 359, Monroe, Mich.
Arnold, Robert B., c/o Tob. By-Products & Chem. Corp., Richmond, Va
†Ashworth, John T., Danielson, Conn.
Audant, Andre, Ent., S. N. P. A., Port au Prince, Haiti
Avery, Paul C., Mission, Tex.

†Badertscher, Amos E., c/o McCormick & Co., McCormick Bldg., Baltimore, Md
Bailey, I. L., Northboro, Mass.
Bailey, John W., Richmond Univ., Va.
Bailey, Stanley F., Box 297, Alhambra, Calif.
Baker, W. C., U. S. D. A. Farm, Taunton, Mass.
Baker, Wm. W., Box 233, Puyallup, Wash.
Ballou, Charles H., Apartado 1368, San José, Costa Rica.
Balzer, August I., Agr. Sub. Sta. No. 4, Beaumont, Tex.
Bare, Clarence O., Box 1525, Sanford, Fla.
Bare, Orlando S., 2325 North 67th St., Lincoln, Neb.
†Barnes, Parker T., 908 Highland Ave., Palmyra, N. J.
Barrett, Ralph E., Box 171, Saticoy, Calif.
Bartlett, Irene L., Div. Insects, U. S. Nat. Museum, Washington, D. C.
Bartlett, Kenneth A., 10 Court St., Arlington, Mass.
Baumhofer, L. G., Coeur d'Alene, Id.
Becton, Edward M. Jr., 707 Washington Ave., Palmyra, N. J.
Bedard, Wm. Delles, Forest Insect Field Sta., Coeur d'Alene, Id.
Benton, Curtis, Box 495, U. S. Ent. Lab., W. Lafayette, Ind.
Berman, H. D., 227 No. 1st St., Minneapolis, Minn.
†Berry, Paul A., 1156 Main St., Melrose Highlands, Mass.
Biederdorf, G. A., Dept. Ent., A. & M. College, Stillwater, Okla.
Billings, Samuel C., R. F. D. 1, Silver Spring, Md.
†Birdsall, R. W., Derris Inc., 79 Wall St., N. Y. C.
Blaisdell, H. L., 20 Sanderson St., Greenfield, Mass.
Blanton, F. S., Box 786, Babylon, L. I., N. Y.
†Blauvelt, Wm. E., 214 Thurston Ave., Ithaca, N. Y.
Bogue, Robert, 3860 Seneca Ave., Los Angeles, Calif.
Boillot, Buell F., 110 Capitol Bldg., Jefferson City, Mo.
Bond, G. L., Box 297, Laurel, Miss.
Botsford, Robert C., Agr. Exp. Sta., New Haven, Conn.
Bottger, Gilbert T., Drawer 359, Monroe, Mich.
Brigham, Wm. Theodore, 77 Elizabeth St., New Haven, Conn.
†Brindley, Tom A., Box 73, Moscow, Id.
Broome, Jr., G. C., Hazelhurst, Miss.
Bronson, Theo. E., 229 Clifford Ct., Madison, Wis.
Brower, A. E., Box 234, Bar Harbor, Me.
Browne, Ashley C., State Office Bldg., Dept. Agr., Sacramento, Cal.
Brubaker, Ross W., 151 W. 11th Ave., Columbus, Ohio.

†Members who attended 1932 meeting.

Brumitt, Sidney C., Grand Bay, Ala.
Brunson, M., Box 415, Picayune, Miss.
†Brunson, Marvin H., Box H., Moorestown, N. J
Buchanan, Dwight, Univ. Farm. St. Paul, Minn.
Buck, J. E., Prosperity, S. C.
Buckner, R. P., R. F D. No. 1, Santa Paula, Calif
Bunn, Ralph, Room 403. Federal Bldg., Salt Lake City, Utah
Burgess, Emory D., 10 Court St., Arlington, Mass
Burtch, Lewis A., Bakersfield, Calif., Room 204
Bushnell, Ralph Judson, 1724 Regent St., Madison, Wis
Butcher, F. Gray, Dept. Ent., Cornell Univ., Ithaca, N. Y
Butcher, Fred D. Bur. Ent., U. S D A, Washington, D C

Calhoun, Stewart L., Box 353, Presidio, Tex
Call, Jr., Anson B., Box 254, Provo, Utah.
Callenbach Jr., John A, 1532 Univ Ave., Madison, Wis
Campbell, Cyril F, Box 791, Harrisburg, Pa
Campbell, L. W., 79 New Montgomery St., San Francisco, Calif
Cannon, Earl W, c o Cal. Spray Chem. Co., San Jose, Calif.
Carpenter, H H, State Plant Board, Houston, Miss
Carpenter, Stanley J., Univ. Tenn., Knoxville, Tenn
Carrol, Francis E, 1915 W. Lawn Ave., Madison, Wis.
Carroll, Mitchell, F. & M. College, Lancaster, Pa.
Carruth, Lawrence A, Dept. of Ent., Cornell Univ., Ithaca, N. Y
Carter, Roscoe H., Bur. of Chem & Soils, Washington, D. C.
Cavitt, Hugh S., Presidio, Texas
Childs, Edwin R., 1201 S. Broadway, Santa Ana, Calif
Christenson, L. Dean, Wellsville, Utah
Clapp, S. C., Mountain Branch Station, Swannanoa, N. C.
Clark, Chas. A., 10 Court St., Arlington, Mass.
Clarke, Wm. H., Exp. Sta., Thomaston, Ga.
Clement, Robert L., 60 N. Sycamore St., W Hempstead, L. I, N Y
Clifton, H. K., New Holland, Ohio.
Cody, L. R., Hall of Justice, San Jose, Calif.
Coffin, Owen, T., c o Leffingwell Ranch, Box 218, Whittier, Calif.
Cole, Jr., Arthur C., Ohio State Univ., Columbus, Ohio.
Collins, D. L., Agr. Exp. Sta., Geneva, N. Y.
Colmer, Robert P., Moss Point, Miss.
†Conklin, James G., Durham, N. H.
Cooper, James F., Box 67, Cornelia, Ga.
Cox, J. A., Agri. Exp. Sta., Geneva, N. Y.
Craig, F. W., 1605 Quarrior St., Charleston, W. Va.
Crane, H. A., Box 935, Marysville, Calif.
Crawford, A. W., Agr. Exp. Sta., Geneva, N. Y.
Crooks, Clarence A., Box 976, Sandusky, Ohio.
Crowley, D. J., Long Beach, Wash.
Culbertson, Raymond E., Lempeter, Pa.
Curl, Chester L., 489 N. Center St., Orange, Calif.

†Members who attended 1932 meeting.

Daniels, L. B., Colo. Agr. College, Fort Collins, Colo.
†Darley, Merrill M., Ohio Agr. Exp. Sta., Wooster, Ohio.
Davidson, Ralph H., Dept. Ent., O. S. U., Columbus, Ohio.
Davis, I. W., Danielson, Conn.
Davis, L. Reid, State College, Ames, Iowa.
Davis, Louis G., 630 S. Whitcomb St., Fort Collins, Colo.
Dawson, J. Carl, Bd. Agr., Jefferson City, Mo.
Dawsey, Lynn H., Box 7, Sta. G., New Orleans, La.
Dean, Fred P., Bur. Ent., Yakima, Wash.
Dean, Ralph W., Box 51, Vassar College, Poughkeepsie, N. Y.
Dearborn, Frederick E., 216 13th St., S. W., Wash., D. C.
DeCoursey, J. Don., 208 W. Nevada Ave., Urbana, Ill.
Deen, O. T., Box 205, Biloxi, Miss.
Deen, R. B., Tupelo, Miss.
Denny, Chas., 5132 Waterman, St. Louis, Mo.
Dicke, F. F., Charlottesville, Va., Box 592.
Dickison, William, Bailey Hall, Cornell Univ., Ithaca, N. Y.
†Dills, L. E., Exp. Sta. Bldg., State College, Pa.
Dimick, Roland E., Room 302 Agr. Bldg., Corvallis, Ore.
†Dirks, Chas. O., Dept. Ent., Maine U., Orono, Me.
Dixon, John W., Independence, Calif.
†Dobbins, Traber N., Bay Springs, Miss.
Doner, M. H., 1532 University Ave., Madison, Wisc.
Donohoe, Huber C., 712 Elizabeth St., Fresno, Calif.
†Dorman, R., 515 No. Sixth St., Vincennes, Ind.
Dorward, Kelvin, 106 Morrill Hall, Knoxville, Tenn.
Douglas, Nelson L., Box 613, Grenada, Miss.
Douglas, W. A., Box 164, Crowley, La.
Douglass, Wm. J., Box 94, Naco, Ariz.
Dove, Walter H., Cia Carbonifera de Sabinas, S. A. Rosita, Coahuila, Mexico.
Drumheller, C. E., c/o Flagg Buckhorn Est., Buena Vista, O.
Duggan, Chas. E., Box 445, San Dimas, Calif.
Durham, Wallace, 2412 E. 57th St., Los Angeles, Calif.
Dutton, W. C., M. S. C. Dept. Hort., E. Lansing, Mich.
Dye, H. W., Niagara Sprayer Co., Middleport, N. Y.

†Ellenwood, W. W., Dept. Agr., Columbus, Ohio.
Esselbaugh, Chas. O., 723 Walnut St., Fostoria, Ohio.
Evans, John Harwood, Oshkosh High School, Oshkosh, Wisc.
Everly, Ray T., 425 Fourth St., Toledo, Ohio.

Fahey, Jack E., Box 1414, Wenatchee, Wash.
Fall, F. L., 313 Montauk Ave., New London, Conn.
Farleman, M. G., 213 Ann St., Box 753, E. Lansing, Mich.
Farlinger, D. F., Cornelia, Ga.
Farmer, Lowell J., Room 403 Federal Bldg., Salt Lake City, Utah.
Fattig, P. W., Box 788, Emory Univ., Ga.
Fey, K. Y., East Hill, Sia-Shih, Checkiang, China.

†Members who attended 1932 meeting.

Fletcher, Fred W., N. Y. State College of Forestry, Syracuse Univ., Syracuse, N. Y.
Fox, Robert Howard, 2312 Shroyer Road, Dayton, Ohio.
Frazier, John M., Sta. A., Box 156, Hattiesburg, Miss.
Freeman, Wm., 314 79th St., Brooklyn, N. Y.
French, Geo. Talbot, Room 1112, State Office Bldg., Richmond, Va.
Frost, L. A., Thayer Int. Bridge, Mercedes, Tex.

Garrettson, Geo. W., 6070 Fairfield St., Los Angeles, Calif
Gates, Leroy M., Lincoln, Neb. R. F. D. No. 6.
Gay, G., 7 Custom House Bldg., Charleston, S. C.
Geissler, Geo. H., 34 Swan St., Lawrence, Mass.
Getzendaner, C. W., Box 233, Puyallup, Wash.
Gibson, L. E., Greenfield, Mass.
Gilbertson, G. J., State College, Brookings, S. D.
Gillette, Claude C., North Rose, N. Y.
Gjullin, C. M., Box 1062, Portland, Ore.
Gnadinger, C. B., 4941 Upton Ave., So. Minneapolis, Minn.
Good, Newell E., 2000 H. St., N. W., Washington, D. C.
Goodgame, L. J., Box 222, Aberdeen, Miss.
Goseco, Frederico P., Silay-Hawaiian Central, Occidental Negros, P. I.
†Gould, E., Kearneysville, W. Va.
Grady, A. G., c/o Sinclair Refining Co., E. Chicago, Ind.
Grady, Howard J., 214 W. 14th St., New York City.
Graham, Castillo, Hancock, Md.
Gram, Ernest, Statens Plantepatologiske, Lyngby, Denmark.
Grant, D. H., R. F. D. No. 1, Scotch Plains, N. J.
Grant, Wilbur, State College, Ames, Iowa.
Gray, John, Box H., Moorestown, N. J.
Gray, Wm. LeVert, Box 433, Natchez, Miss.
Green, Chas. E., Limoneira Ranch, Santa Paula, Calif.
Green, E. C., 1101 W. Green St., Urbana, Ill.
Green, G. D., Ent. Dept. State College, Bozeman, Mont.
Gregory, Frederick W., Fed. Bldg., Niagara Falls, Ont., Canada.
Griffin, Edward L., Food, Drug, & Insecticide Adm., Wash., D. C
Griffin, S. W., P. O. Box 1285, Wenatchee, Wash.
Griffith, Clement Hall, Div. Ent., St. Paul, Minn.
Gross, Cecil R., Bur. Chem. Soils-Insect Div., Wash., D. C.
Gunderson, A. J., c/o Sherwin-Williams Co., Cleveland, Ohio.
Grout, Roy A., Hamilton, Ill.
Guthrie, Howard Emerson, 139 Sheldon St., Ames, Iowa.
Guy, H. G., Ohio State Univ., Columbus, Ohio.
Gwin, Clarence M., 308 N. Blount St., Madison, Wisc.
†Gwinner, Chas. C., 6300 State Rd., Philadelphia, Pa.

†Haas, Louise Elizabeth, Zool. Dept., I. S. C., Ames, Iowa.
Haasis, Frank A., Dept. Plant Path., Cornell Univ., Ithaca, N. Y.
Haden, Wm. R., U. of Del., Camden Substa., Box 1., Wyoming, Del.

†Members who attended 1932 meeting.

Haines, Kenneth A., Dept. Ent., O. S. U., Columbus, Ohio.
Hambleton, Edson J., Escola de Agricultura, Vicosa, Minas Geraes, Brazil
Hamilton, Donald W., Cornelia, Ga.
Hammer, Oscar H., Dept. Ent., Cornell Univ., Ithaca, N. Y
Hanson, Arthur J., W. Wash. Exp. Sta., Puyallup, Wash.
Harris, J. A., N. C. Dept. Agr., Raleigh, N. C.
Harrison, P. K., Exp. Sta., Baton Rouge, La.
Hartnack, Hugo, 608 S. Dearborn St., Box 5, Chicago, Ill
Hatcher, R. F., 107 Lee St., Winchester, Va.
Hatten, M. J., Wiggins, Miss.
Haug, Gordon W., Dept. Ent., O. S. U., Columbus, Ohio
Hawkins, J. H., Agr. Exp. Sta., U. of Maine, Orono, Me
Haydak, M. H., 1532 Univ. Ave., Madison, Wis.
Heming, W. E., Ont. Agric. Coll., Guelph, Ont., Can.
Henkels, R. M., 446 Church Lane, Philadelphia, Pa.
Hensill, Geo. S., Agr. Hall, Univ. of Cal., Berkeley, Calif.
Hering, Paul E., Dept. Ent., Cornell Univ., Ithaca, N. Y.
Hertzog, P. H., Hightstown, N. J
Hill, Sam O., 10 Court St., Arlington, Mass
Hillis, Orin A., Box 173, Hermiston, Ore.
Hines, Chesley, Yazoo City, Miss.
Hinnenkamp, Frieda B., 1306 1st Ave., W. Seattle, Wash.
Hixson, Homer, Ent. Dept., Stillwater, Okla.
Hockenyos, Geo. L., 1003 Oregon St., W. Urbana, Ill.
Hodson, Alexander C., Zool. Dept., Univ. of Minn., Minneapolis, Minn
Hoffman, Clarence H., Div. Ent., Univ. Farm., St. Paul, Minn.
Hoidale, P. A., 503 Rio Grande Natl. Life Bldg., Harlingen, Tex.
Holdridge, Abby, 1700 L St., N. W., Washington D. C
Hollingsworth, W. B., Picayune, Miss.
Hollister, Wesley O., c/o Davey Tree Expt. Co., Kent, Ohio.
Hookum, Don W., Dept. Ent., College Park, Md.
Hopkins, C. O., State Univ., Baton Rouge, La.
Hopkins, F. G., 406 Morrill Hall, Knoxville, Tenn.
Horsfall, Wm. R., Dept. Ent., Cornell Univ., Ithaca, N. Y
Horton, Geo., Box 5215 State College, Raleigh, N. C.
Horton, Harvey A., Carnegie, Caddo Co., Okla.
Hoskins, Wm. M., 111 Agr. Hall, U. of Cal., Berkeley, Calif.
Hoyt, Avery S., P. Q. C. A., Dept. of Agr., Washington, D. C.
Hudson, G. H., Plattsburg, N. Y.
†Hull, Frank M., 1104 Univ. St., Univ. of Miss, Miss.
Hunt, Ronald W., Box 62, Whittier, Calif.
Hunt, Wm. Theodore, Box 871, Alpine, Tex.
Hutchinson, Robert N., 225 Italia St., Covina, Calif.

Irish, C. F., 418 105th St., Cleveland, Ohio.
Irvin, F. V., Box 1355, Phoenix, Ariz.

Jameson, John H., 125 Norway Rd., Bangor, Me.

†Members who attended 1932 meeting.

Janes, Melvin, Ent. Dept., State College, Logan, Utah.
Jenkins, Lee, 320 W. Myrtle St., Ft. Collins, Colo.
Johnson, Paul H., Marionville, Mo.
Johnson, Philip C., Giannini Hall., U. of Cal., Berkeley, Calif.
Johnston, Harmon R., Box 5215, State College Sta., Raleigh, N. C.
Jones, Elmer T., 128 S. Minneapolis Ave., Wichita, Kans.
Jones, Edward W., Box 616, Walla Walla, Wash.
Jones, Geo. D., 106 Whitten Hall, Columbia, Mo.
Jones, Howard A., Bur. Chem. & Soils, Washington, D. C.
Jones, Leland Jackson, 473 4th Ave., Salt Lake City, Utah
Jones, L. S., State Dept. of Agr., Sacramento, Calif.
Jones, M. L., 2109 Gerber Ave., Sacramento, Calif.
Jones, R. M., Fruit Exp. Sta., Mountain, Grove, Mo.
Jones, Sloan E., Div. Ent., College Station, Tex.
Jones, Sydney Carroll, Dept. Ent., O. S. C., Corvallis, Ore.
Jones, Victor E., U. of Idaho, Pocatello, Idaho
Jones, W. W., 1048 10th St., Douglas, Ariz.
Jorgensen, Drew D., American Fork, Utah
Jung, Goey Park, Bur. Ent., Nanking, China

Kagy, J. Franklin, State College, Ames, Iowa.
Kamal, Mohammed, Cotton Research Board, Giza, Egypt
Kearns, Clyde W., Univ. Ill., Urbana, Ill.
Keck, Chester B., Box 340, Honolulu, H. T.
Kegley, Fred W., 406 Morrill Hall, Knoxville, Tenn.
Keler, Stefan, Pantswowy Inst., Nankowo-Rolniczy, Bydgoszaz, Poland.
Kelley, R. W., Box 1959, Orlando, Fla.
Kelly, Sam G., 1600 Houston St., Manhattan, Kans.
Kennedey, R. D., 129 Morrison Ave., West New Brighton, Staten Island, N. Y.
Kent, Virgil F., 308 W. Elm St., Monroe, Mich.
Kessler, K. L., Box 603, LaHabra, Calif.
Kidder, Nathaniel T., Milton, Mass.
Kile, Henry J., 1113 Holly St., Nashville, Tenn.
Kinsley, Chas. H., Box 423, Sacramento, Calif.
Kirkpatrick, Albert F., R. D. 1., Box 475, Monrovia, Calif.
Knipling, Edw. F., Drawer 48, Galesburg, Ill.
Knight, Hugh, Box 382, Upland, Calif.
Koch, Karl, Dept. Econ. Ent., U. Wis., Madison, Wis.
Kohls, Glen M., Hamilton, Montana.
Kraus, E. J., U. of Chicago, Chicago, Ill.
Kutchka, G. M., 600 Whitney Ave., Wilkinsburg, Pa.

Lacroix, Donald S., Pleasant St., Amherst, Mass.
LaFollette, J. R., 101 Ridge Rd., Whittier, Calif.
Lanchester, Horace P., Parma, Idaho.
Landis, Birely J., 151 W. 11th Ave., Columbus, Ohio.
Landon, Wm. E., R. F. D., San Dimas, Calif.
Lebert, Carol D., Box 2008, Phoenix, Ariz.
Lehman, Russell S., Box 616, Walla Walla, Wash.

Lewis, C. W., 134 So. 2nd St., Phila., Pa
Lilly, John H., 1532 Univ. Ave., Madison, Wis.
Lindgren, David L., Univ. Farm, St. Paul, Minn.
Little, V. A., Box 225, College Station, Tex.
Livingstone, Erskine M., 200 Bland St., Richmond, Va.
Lobdell, Mrs. R. N., Everglades Exp. Sta., Belle Glade, Fla.
Loding, C. P., 166 Houston St., Mobile, Ala.
Longan, E. W., State Office Bldg., Sacramento, Calif.
Lopez, A. W , Box 27, LaCarlota, Occidental Negros, P. I.
Lopp, O. Vernon, 132 State House, Indianapolis, Ind.
Lott, Earl, Moorestown, N. J.
Lyon, Scott C., Box 491, Davidson, N. C.

Mabee, W. B., Expt. Sta. Bldg., State College, Pa.
MacAndrews, A. H., N. Y State Col. of For., Syracuse, N Y.
†MacCreary, Donald, Dept. Ent., Newark, Del.
Manson, Geo. F., Ent. Lab., Lethbridge, Alberta, Canada.
†Madden, Archie H., Box 592, Charlottesville, Va.
Marsh, H. Lawrence, Box 218, Whittier, Cal.
Marshall, James, Wash. State College, Exp. Sta., Wenatchee, Wash
Marston, L. Chester, Jr., Dept. Biol., U. Toronto, Toronto, Canada.
Martin, J. F., Bur. Plant Ind , Washington, D. C.
Mason, Horatio C., 151 W. 11th Ave., Columbus, Ohio.
Mathes, R., 214 So. Macomb St., Monroe, Mich.
†Maughan, F. B., Cornell Univ., Ithaca, N. Y.
Mayer, Lionel A., 508 Seabord Natl. Bldg., Norfolk, Va.
McCampbell, Sam, C., Zool. Bldg., Colo. Agr. Coll., Ft. Collins, Colo
McDonald, R. E., Box 798, San Antonio, Tex.
McEvoy, J. A., 136 Church St., Putnam, Conn.
McGarr, Rex L., Box 374, Tallulah, La.
McGough, James Marion, Box 284, Morton, Miss.
McGovran, Edw. R., State Ent. Bldg., Urbana, Ill.
McKay, R. S , Owensville, Ohio.
McNally, A. Gordon, 390 Colborne St., London, Ont., Canada
McNeel, T. E., Zellwood, Fla.
Meacham, Frank B., State College, Raleigh, N. C.
Mechling, Edw. A., Line St. & Coopers Creek, Camden, N. J.
Mendenhall, Eugene W., 97 Brighton Rd., Columbus, Ohio.
†Merino, Gonzalo, Dept. Ent., O. S. U., Columbus, Ohio.
Merrill, D. E., 501 W. Sycamore St., Rogers, Ark.
Merritt, James M., Haslett, Mich.
Meymarian, A. T., 8/1/40 New Street, Bagdad, Iraq.
Michelbacher, A. E., 814 Miramar Ave., Berkeley, Calif.
Millar, P. H., State Plant Bd., Little Rock, Ark.
Millender, H. C., Box 685, Houston, Tex.
Miller, John A., 36 Charles St., Wakefield, Mass.
Miller, Albert C., 381 W. 9th Ave., Columbus, Ohio.
Miller, F. W., U. of Pittsburgh, Pittsburgh, Pa.

†Members who attended 1932 meeting.

Mills, Alfred S., Box 223, San Juan, P. R.
Mills, Harlow B., Dept. Ent., Ames, Iowa
Mills, James Jr., Glenn Co., Hamilton, Calif.
Milton, Jack, Box 148, Corinth, Miss.
Mohr, Carl, State Nat. History Sur., Urbana, Ill.
Monk, J. W., Donna, Tex.
Montgomery, B. Elwood, Purdue U., Lafayette, Ind.
Moody, D. C., Cornelia, Ga.
Moody, Delbert L., Box 132, Presidio, Tex.
†Moore, Warren, Richmond, Va.
Morofsky, Walter F., Dept. Ent., E. Lansing, Mich.
Morrill, Austin Winfield Jr., 200 Bland St., Richmond, Va.
Morris, Earl L., 812 E. 1st St., Santa Ana, Calif.
Morrison, H. E., Agr. Exp. Sta., Wooster, Ohio
Morton, F. A., U. S. Ent. Lab., Bozeman, Mont.
Munger, F., 7710 Blair Rd., Takoma Park, Md.
Murillo, Luis Maria, Dept. Agr., Bogota, Colombia, S. A.
†Murphy, D. F., Bath Rd., R. D. No. 1, Bristol, Pa.
Murray, Chas. W., Box 1285, Wenatchee, Wash.
Myers, John H., Moweaqua, Ill.
Myers, L. E., 204 State Office Bldg., Los Angeles, Calif.

Neil, Fred A., 12 So. Market St., Boston, Mass.
Nel, R. I., Naga Hoeta Estate, Sumatra E. C., Pematang Siantar
†Nelson, F. C., 118 Chandler Ave., Roselle, N. J.
†Nelson, R. H., U. S. Greenhouse Lab., Arlington Farms, Va.
Nettles, Wm. Carl, Clemson College, S. C.
Newbegin, I. B., Wakefield, Mass.
Newton, J. H., Paonia, Colo.
Newton, R. C., 518 Haven St., Medford, Ore.
Noble, Loyd Wm., Tallulah, La.
Norris, Robert K., Pinnacle Packing Co., Medford, Ore.

O'Dell, John H., Box 1857, Phoenix, Ariz.
Ohlendorf, Walter, Tlahualilo, Durango, Mex.
Osterberger, B. A., Exp. Sta., Baton Rouge, La.

Padget, L. J., Box 585, Indio, Calif.
Parish, H. E., Box 487, Menard, Tex.
Parker, Lawrence B., U. S. Ent. Lab., Moorestown, N. J.
Parr, Thad J., Yale Forest School, New Haven, Conn.
Pearson, Allen M., State College, Ames, Iowa.
Peet, Charles H., c/o Rohm & Haas Co., Bristol, Pa.
Peets, Norman D., Box 144, Brookhaven, Miss.
Pegler, Harold C., Box 2833, Los Angeles, Calif.
†Pepper, Bailey B., Dept. Ent., Agr. Exp. Sta., New Brunswick, N. J.
Pepper, James H., Dept. of Ent., State College, Bozeman, Mont.
Perry, Robert A., 3720 W. 59th Place, Los Angeles, Calif.

†Members who attended 1932 meeting.

Phillips Griffin L Baldwyn Miss
Phillips Saul Conservation Commission Albany N Y
Pierce Wm C Box 563 Brownwood Texas
Piller A L State Capitol Annex Madison Wisc
Plumb Geo Henry 17 Compton Street New Haven Conn
Plummer Chas C Rancho Amanalco Cupenavaca Morelos Mexico
Pope J B, Piura Peru S A
Powers E B 133 E Hillvale St Knoxville Tenn
Preston Roger Lee 1217 5th Ave Grinnell Iowa
Price L L L S U Baton Rouge La
Primm James K 992 Kingsley Ave Pomona Calif
Proper Argyle B Bur Ent Melrose Highlands Mass

†Rainwater Clyde F Delta Lab Tallulah La
Reed I B Box 146 Chadbourne N C
Reed Thomas Walter Exp Sta Geneva N Y
Remy Theron P 2314 Chrysler Bldg New York City
Reynolds Geo D Insecticide Testing Lab Route 1 Silver Spring Md
Rice Paul L Moscow Idaho
Riddle Hazel W N D A C Dept of Ent Fargo N D
Ries Donald T Cranbrook Institute of Science Bloomfield Hills Michigan
Riley M K Univ of Hawaii Honolulu Hawaii
Rippey H K 5143 E Washington St Indianapolis Ind
Roaf J R 402 N 17th St Corvallis Oregon
Roark C B Estacion Experimental Canete Peru
Roberts J Harvey Box 376 University Station Baton Rouge La
Roberts Raymond University Pl 1329 N 41st Lincoln Neb
Rolfs Archie R Box 243 Yakima Washington
Rolfs P H Vicosa E F Leopoldina Minas Geraes Brazil
Romney V E Grand Junction Colorado
Roney James N Plant Lice Lab Dickinson Texas
Root E R Medina Ohio
Roseling C F c/o Progreso Development Co Weslaco Texas
Rothe C H Box 1117 Phoenix Arizona
Roullard Fred P 220 Holland Bldg Fresno Calif
Russell Ernest E Ent Lab Tempe Arizona
Ryberg Milton L c/o Boyce Thompson Inst Plant Research Yonkers N Y

Sakimura Kay Univ of Hawaii Honolulu Hawaii
Sanchez Ernesto e Estrada Calle 20 No 21 Entre 15 Vedado Habana Cuba
Sankowsky Nicholas A S O (N J) Dev Co Box 243 Elizabeth N J
Savage John R O Agr Exp Station, Wooster Ohio
Schaeffer, Melle C Inst de Recherches d'Insecticides 23 rue du Laos Paris France
Schenk, Gilbert 700 W 74th St, Kansas City Mo
Schlupp, Wm Francis Newcomerstown, Ohio
†Schmitt, John B Dept of Ent, Rutgers Univ, New Brunswick, N J
Schopp Ralph, U S Ent Lab Sumners, Wash
†Schread, John C, 247 Vine St, Bridgeport Conn

†Members who attended 1932 meeting

Schwardt, H. H., Ark. Univ., Div. of Ent., Fayetteville, Ark.
Sellers, Wendell F., 217 Main St., Melrose, Mass.
Shands, W. A., 1630 N. 7th St., Grand Junction, Colo.
Shaw, J. Gilbert, 808 Alabama St., Lawrence, Kansas.
Sheaffer, Frank E., 626 W. 38th St., Indianapolis, Ind.
Sheldon, Howard B., Santa Paula, Calif.
Shields, S. E., 400 Morrill Hall, Univ. of Tenn. Knoxville, Tenn.
Shropshire, L. H., Box 352 Arlington Heights, Ill.
Simmons, Samuel W., Bur. of Ent., Washington, D C
Simonton, Wm. A., State College, Ames, Iowa.
†Simpson, G. W., Holmes Hall, Orono, Maine
Singleton, J M., Hidalgo, Texas
Slack, Torbert, Box 773, Lake Charles, La.
Sleesman, George B., Box 23, No Glenside, Pa.
Slocum, Burl A., North China Union Language School, Peiping, China.
Smith, C. L , R. F. D , No. 5, Wesson, Miss.
Smith, F. A , Senatobia, Miss.
Smith, George A., Dept. Conservation 30 Somerset St , Boston, Mass.
Smith, George E , Albion, N. Y.
Smith, W. F., No. 1811 East Walnut St., Pasadena, Calif
Soudek, Stepan, Brno, Czechoslovakia
Spangenberg, Herbert, 137 N. San Joaquin St , Stockton, Calif.
Spawn, G. B., College Sta., Brookings, S. D
Spies, J. R., College Park, Maryland
Stabe, Henry A., Lansing, Iowa.
Stanley, W. W., Agric. Exp. Sta., Knoxville, Tenn.
Stage, H. H., Box 1062, Portland, Oregon.
Steenburgh, W Elgin, c/o Dominion Parasite Lab., 228 Dundee St , E., Belleville, Ontario, Canada.
Steinweden, John B., 149 California St., San Francisco, Calif.
Stevenson, W. A., Box 1910, Tucson, Arizona.
Stewart, Morris A., Dept. Biol., Rice Inst., Houston, Texas.
Stiles, Charles F., Box 37, Stillwater, Oklahoma.
Stirland, La Grande, Providence, Utah.
Stitt, Lloyd L., U. S. Ent. Lab., Tempe, Arizona.
Stone, M. W., Box 297, Alhambra, Calif.
Strand, Thomas P., c/o Cal. Spray Chem. Co., Yakima, Wash.
Sullivan, Wm. N., 7710 Blair Road, Takoma Park, Maryland.
Summerland, S. A., Bentonville, Arkansas.
Swingle, Millard C., 7710 Blair Road, Takoma Park, Md.
Symonds, Clarence M., Bur. of Ent., Melrose Highlands, Mass.

Talbert, T. J., Hort. Bldg., Whitten Hall, Columbia, Mo.
Tate, H. D., State College, Ames, Iowa.
Thompson, B. T., P. O. Box 514, Summit, N. J.
Thompson, Friar M. Jr., Dept. Ent., Rutgers Coll., New Brunswick, N. J.
Thompson, G. A., Box 187, Kingston, R. I.
Thompson, Robert W., Dept. Ent., O. A. C., Guelph, Canada.

†Members who attended 1932 meeting.

Thompson, William L., Lake Alfred, Florida.
Thomson, J. R., Jr., Box 445, Fort Valley, Georgia.
Thurber, George A., State College, Ames, Iowa.
Tibbets, H. A., c/o Cal. Spray Chem. Co., Berkeley, Calif.
†Tischler, Nathaniel, 215 Chamberlain Place, Ames, Iowa.
Townsend, James Farley, 278 Canner St., New Haven, Conn.
Townsend, Lee H., Div. of Ent., Univ. of Ill., Urbana, Ill.
Toyne, Arthur, 404 Cypress Ave., Pasadena, Calif.
Travis, Bernard, Zool. Dept., I. S. C., Ames, Iowa.
Tubbs, Dixson W., Tustin, Calif
Tuckett, J. E., Indio, Calif

Ulman, Paul T., European Corn Borer Control, Auburn, Ind
Van Allen, Thomas S., 902 Charleston St, Mobile, Ala.
Vanderford, H. T., Maben, Miss.
Van der Meulin, P. A., Rutgers University, New Brunswick, N. J
Van Horn, Clair, Room 1 Masonic Bldg., Meadville, Pa.
Vickery R. K., 1118 Oxford St., Berkeley, Calif
Vinzant, M. G., 1401 Buena Vista Ave., Laredo, Texas.
Vogel, Matthew A., Agric. Exp. Sta., Wooster, Ohio

Wagner, George B., Flour Mill Insect Lab., 1318 E. Armour Boulevard, Kansas City, Missouri.
Walker, G. L., Durham, N. H.
Wallis, Robert L., Box 348, Estancia, New Mexico.
Warren, Allen J., 59 Lincoln St., New Haven, Conn.
Waters, Harold A., B. & Z. Bldg., O. S. U., Columbus, Ohio.
Watson, Lloyd R., Alfred, N Y.
Watts, J. G., Clemson College, S. C.
Weed, C. M., State Normal School, Lowell, Mass.
Wells, Arthur B., Bryn Athyn, Pa
†Westgate, W. A., Durham, N. H.
Wheeler, Andrew J., Madison, Tenn.
Whitten, Russell R., 104 Ashland St., Melrose Highlands, Mass
Wilbur, Donald Alden, Dept. of Ent., K. S. C., Manhattan, Kans.
Wilcoxon, F., Boyce Thompson Institute, Yonkers, N. Y.
Wilford, B H., Univ. of Mich., Ann Arbor, Mich.
Willard, H. J., Moorestown, N. J.
Willey, C. R., Room 1112, State Office Bldg., Richmond, Va.
Williams, L. L., Box 374, Dover, Delaware.
Williams, Orville L., Bayard, Iowa.
Williams, V. E., 1324 Elm Ave., San Gabriel, Calif.
Williamson, Amis L., International Bridge, Hidalgo, Texas.
Williamson, Warren, R. D. 5, Galesburg, Ill.
Wilson, G. R., 1538 Peru St., Alameda, Calif.
Winchester, H. I., R. D. 1, Wakefield, Mass.
Wisecup, C. B., Sanford, Florida.
Woke, Paul A., Bur. of Ent., Tallulah, La.

†Members who attended 1932 meeting.

Wolfenbarger, D. O., Farm Bureau, Albion, N. Y.
Woodrow, A. W., Dairy Bldg., Cornell Univ., Ithaca, N. Y.
Woodside, A. M., 627 W. Frederick St., Staunton, Virginia.
Woodworth, Chas. E., Route 2, Box 50A, Walla Walla, Wash.
Wray, David, L. Jr., Dept. of Agric., Raleigh, N. C.
Wright, Percy F., 513 S. School St., Lodi, Calif.
Wygant, N. D., N. Y. St. College of Forestry, Syracuse, N. Y.

York, Converse, H., 304 Madison Ave., Pomona, Calif.
York, George T., Box 488, Davis, Calif.
Young, H. C., Box 212, Enfanla, Oklahoma.
Young, H. D., Bureau of Chemistry & Soils, Washington, D. C.

Zeimet, Carlo, Bureau of Ent. Washington, D. C.
Zeisert, E. E., R. R. 6, Brookville, Ohio.
Zimmerman, Mrs. H. K., 317 Kensington Ave., Astoria, Oregon.
Total number of Associate Members, 523

FOREIGN MEMBERS

Anderson, T. G., Nairobi, British East Africa
Aulio, Costilla Dr. Manuel, Laboratorio de la Fauna Forestal Espanola, Ferraz, 40 Madrid, Spain

Ballou, H. A., West Indian Agricultural College, St Augustine Trinidad, West Indies
Bordage, Edmond, Directeur de Musee, St. Denis, Reunion
Brain, Charles K., University of Stellenbosch, Stellenbosch C P South Africa.

Carpenter, Dr George H., University of Manchester, Manchester, England
Collinge, W E 55 Newhall St., Birmingham, England

Danysz, J., Laboratorie de Parasitologie, Bourse de Commerce, Paris, France
DeBussy, L. P., Kolonial Instit., Mauritskade 65–66, Amsterdam, Holland

Escherich, K., Forstliche Versuchsaustalt, Universitat, Munich, Germany.

Filipjev, T. N., Gertzena 44, Leningrade, Russia
French, Charles, Department of Agriculture, Melbourne, Australia
Froggatt, W. W., 12 Young St., Croyden, Sydney, New South Wales

Goding, F. W., Box 448, Livermore Falls, Maine, U. S. A
Grasby, W. C., 6 West Australian Chambers, Perth, West Australia
Green, E. E., Way's End, Beach Ave., Cramberley, Surry, England

Harukawa, Chukichi, Kurashiki, Okayama-Ken., Japan.
Herrera, A. L., Care Secretaria de Agricultura y Fomento, Mexico, D. F. Mexico.
Hill, Gerald F., 5 Clifton Rd., Hawthorn, Melbourne, Australia.
Horvath, Dr G., Museum Nationale Hungaricum, Budapest, Hungary.

Jablonowski, Josef, Entomological Station, Budapest, Hungary.
Jack, Rupert W., Salisbury, Rhodesia, South Africa.
Johnson, Thomas H., University of Brisbane, Queensland, Australia.
Kulagin, Nikolaie M., Petrovsky-Rasumovsky Academy, Petrovsko-Rasumovskoie, Moscow, Russia.
Kuwana, S. I., Imperial Agricultural Experiment Station, Yokohama, Japan

Lounsbury, Charles P., 795 Church St., East, Pretoria, South Africa.

Mally, C. W., University of Stellenbosch, Stellenbosch, C. P., South Africa
Marchal, Dr. Paul, 16 Rue Claude-Bernard, Paris, France.
Mokrzecki, Dr. Sigismond, Director, Instit. of Forest Protection and Entomology Skierniewice, Poland.
Mussen, Charles T., Hawkesbury Agricultural College, Richmond, New South Wales

Nawa, Yashushi, Entomological Laboratory, Kyomachi, Gifu, Japan.
Newstead, Robert, University School of Tropical Medicine, Liverpool, England

Parker, Theodore, Leeds University, Leeds, England
Porter, Carlos E., Casilla 2352, Santiago, Chili
Pospielow, Dr. Waldemar, Bureau of Entomology, Morskaya 44, Petrograd, Russia

Read, Charles S., Mendoza, Argentine Republic, South America
Rosenfeld, A. H., Am. Sugar Cane League, 1005 New Orleans Bank Bldg., New Orleans, La
Ruzkowski, J. W., Solacka, Poznan, Poland

Sajo, Prof. Karl, Godollo-Veresegyhaz, Hungary.
Scaramuzza, L. C., Camaguey, Cuba
Schoyen, Prof. W. M., Zoological Museum, Oslo, Norway.
Severin, Prof. G., Curator Natural History Museum, Brussels, Belgium
Silvestri, Dr. F., R. Scuola Superiore di Agricoltura, Portici, Italy
Stellwaag, Dr. Frederich, Neustadt, a. d. Haardt, Germany.

Theobald, Frederick V., Wye Court, Wye, Kent, England.
Thompson, Rev. Edward H., Franklin, Tasmania.
Tillyard, R. J., Cawthron Institute of Scientific Research, Nelson, New Zealand.
Tragardh, Ivor, Experimental Faltat, Stockholm, Sweden.
Trouvelot, Bernard, Inst. Agr. Research, Paris, France.
Tryon, H., Queensland Museum, Brisbane, Queensland, Australia.

Urich, F. W., Department of Agriculture, Port of Spain, Trinidad, West Indies.

Total Number of Foreign Members, 51
Life Members, 6
Grand Total of Members, 1224

Forty-Sixth Annual Meeting of the

American Association of Economic Entomologists

Boston, Mass.

December 27 to 29th, 1933

FORTY-SIXTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, BOSTON, MASS.

December 27 to 29th, 1933

The 46th Annual Meeting of the American Association of Economic Entomologists will be held at Boston on the above dates. Sessions on Wednesday, December 27, will be held in the Hotel Bradford, which is also Hotel Headquarters. Sessions on Thursday and Friday, December 28 and 29th, will be held in Austin Hall, Harvard University, Cambridge.

The schedule of meetings has been arranged as follows:

Wednesday, December 27.
- Section of Plant Quarantine and Inspection, sessions 1:30 P.M. and 7:30 P.M.
- Section of Apiculture, session 1:30 P.M.
- Section of Extension, session, 7:30 P.M.
- Beekeepers Smoker, 7:30 P M

Thursday, December 28. Opening Session of General Association, 9:30 A.M.
Afternoon Sessions, 1:30 P.M.
Thursday Evening, the Entomologists Dinner.

Friday, December 29. General Session 9:30 A.M.
Afternoon, Symposium on the Spray Residue Problem, 1:30 P.M
Friday Evening. Final Business Session, 7:30 P.M.

OTHER MEETINGS

The Annual Meeting of the American Association for the Advancement of Science, its sections and affiliated societies will be held December 27 to January 2.

The Entomological Society of America will open its meeting on Thursday morning, December 28, and continue through Friday, December 29. The annual public address before that society will be delivered by Dr. Frank E. Lutz of New York City on Thursday evening. Members of our Association are cordially invited to attend this session.

HOTEL HEADQUARTERS

Hotel headquarters have been secured at the Hotel Bradford. The special convention rates are:

Room with bath, one person—$2.50, $3.00, $3.50, $4.00.

Room with bath, two persons—$3.50, $4.00, $4.50, $5.00 and $6.00.

GARAGE—PARKING

Excellent parking and garage facilities are available near the Hotel Bradford. The Eliot Street Garage (heated) is one block from the hotel. Rates: $1.00 per night. There are several parking spaces within a block of the Hotel with rates of $.50 per night. At the Tremont and Broadway Space quotations have been offered of three days for $1.00, or $2.00 per week.

RAILROAD RATES

Reduced railway rates by the certificate plan have been granted by almost all railroads in the United States and Canada. Persons attending the meeting should purchase a first class, one way ticket to Boston and secure a standard certificate form The certificate must be validated in the registration office. The validated certificate allows continuous passage, return ticket for one-third of the regular fare by the same route before January 5, 1934. Tickets to Boston must be purchased between December 21 and December 23, both dates inclusive. Return tickets must be purchased by January 5.

Special fares have been announced by railroads in the Central and Trunk Line passenger associations. These tickets will be on sale December 14 to January 1 and will have a return limit of January 15, 1934. The rate of these special fares will be on round trip fare basis of one and one-ninth times the regular first class, one way fare. Consult local agents for most favorable rates.

REGISTRATION

The Headquarters of the American Association for the Advancement of Science for registration and validation of certificates will be located in Memorial Hall, Harvard University. Fee for registration, validation, etc., will be $1.00.

ENTOMOLOGISTS' DINNER

The Annual Entomologists' dinner will be held on Thursday evening, December 28, in the Hotel Bradford. Further notice of the place and hour will be given at the Wednesday and Thursday sessions.

MEMBERSHIP

Applications for membership can be secured from the Secretary or from the Committee on Membership. These should be filled out,

properly endorsed and filed with the Membership Committee on or before December 28. Each application must be accompanied with a fee of $4.00.

A. A. A. S. MEMBERSHIP

The American Association for the Advancement of Science is granting this year to members of affiliated societies, the privilege of joining that Association without the payment of the usual entrance fee.

Application cards are available through the Permanent Secretary of that Association.

PROGRAM

Wednesday Afternoon Session, December 27, 1:30 P.M. Hotel Bradford, Parlor A

SECTION OF PLANT QUARANTINE AND INSPECTION

R. W. LEIBY, *Chairman* S. B. FRACKER, *Secretary*

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, R W Leiby, Raleigh, N. C.

1. Developments in Pest Suppression in 1933. L. A. Strong, Washington, D. C.
2. Gipsy Moth Work East of the Barrier Zone and in Pennsylvania and New Jersey in 1933. A. F. Burgess, Greenfield, Mass
3. Protection Given the Country by the Port Inspection Service. E. R. Sasscer, Washington, D. C.
4. Outbreak of an African Moth in Stored Senna. H. B. Weiss and E. G. Rex, Trenton, N. J.
5. The New Soil Disinfectant Employed in Potato Wart Eradication in Pennsylvania. R. E. Hartman, Hazleton, Pa.
6. Insect Findings of Recent Years Which are or May Become of Interest to Nursery Inspectors and Plant Quarantine Officers. J. A. Hyslop, Washington, D. C.
7. Developments in Bulb Pest Control with Special Reference to Lily Thrips, Gladiolus Thrips, and Narcissus Flies. C. A. Weigel, Washington, D. C.
8. The Tomato Pinworm in Eastern Pennsylvania. T. L. Guyton, Harrisburg, Pa.

Program

Wednesday Evening Session, December 27, 7:30 P.M. Hotel Bradford, Parlor A

9. The European Earwig as a Pest in Rhode Island. A. E. Stene, Providence, R. I.

10. The New Outbreak of the Dutch Elm Disease. R. Kent Beattie, Washington, D. C.

11. Vapor-Heat Treatment and Other New Methods of Disinfecting Plant Materials. L. A. Hawkins, Washington, D. C.

12. Plant Quarantine Legislation Supported by Numerous Court Decisions. S. B. Fracker, Washington, D. C.

13. Prevention of Spread of the European Pine Shoot Moth A Committee Report. H. L. McIntyre, Albany, N Y.

14. Additional Inspection of Nurseries on Account of European Pine Shoot Moth. W. E. Britton, New Haven, Conn

15. Some Peculiarities of State Regulations Concerning the Movement of Nursery Stock and Comments. A. G. Ruggles, St. Paul, Minnesota.

16. Report of the National Plant Board. W. C O'Kane, Chairman, Durham, N. H.

17. Reports of the Regional Boards:

The Eastern Plant Board. E. N. Cory, Secretary, College Park, Md.

The Central Plant Board. P. T. Ulman, Secretary, Indianapolis, Ind.

The Southern Plant Board. J. H. Montgomery, Secretary, Gainesville, Florida.

The Western Plant Quarantine Board. A. C. Fleury, Secretary-Treasurer, Sacramento, Calif.

Report of Resolutions Committee.

Report of Nominating Committee.

Selection of Officers.

Adjournment.

Program

Wednesday Afternoon Session, December 27, 1:30 P.M. Hotel Bradford, Parlor B

Section of Apiculture

W. E. Britton, *Chairman* W. E. Dunham, *Secretary*

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, W. E. Britton, New Haven, Conn. "Miscellaneous Problems in Beekeeping."

1. Broodrearing in the Honeybee Colony. J. A. Munro, Fargo, N. D.

Results of brood measurements conducted on package and overwintered colonies of bees.

2. Adult Bees Dying on Spotted Loco. George H. Vansell and William Watkins, Davis, California.

Report of search for cause of "Nevada Bee Disease" with the finding of honey bees dying on the above plant.

3 Spray Poison in the Yakima Valley R. L. Webster and Arthur Crews, Pullman, Washington.

The use of arsenate of lead in large quantity for the control of the Colorado beetles in the Yakima Valley, Washington, in 1933 resulted in extremely heavy losses to colonies of commercial beekeepers and the smallest honey crop in the history of commercial beekeepers.

4. Planning an Extension Project in Beekeeping. E. J. Anderson, State College, Pa.

5. Studies in the Physical Characteristics of some Massachusetts Honey Bees. C. R. Kellogg, Amherst, Mass.

6. Studies on European Foulbrood and Parafoulbrood. C. E. Burnside, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

Two theories exist regarding the etiology of European foulbrood of bees; namely, (1) That this decrease is caused by ***Bacillus pluton*** and that ***Bacillus alvei***, ***Streptococcus apis***, and ***Bacterium eurydice*** are distinct species constantly associated with European foulbrood as secondary invaders, and (2) That ***B. pluton*** is a stage in the life history of ***B. alvei***. Results of experiments seem to indicate that ***B. alvei*** is an unstable organism capable of growing as a sporogenic rod, or as a coccoid. Results also indicate that parafoulbrood is caused by ***Bacillus para-alvei***, a recently discovered bacterium which appears related to ***B. alvei*** and likewise is capable of growing as a rod or a coccoid. By special culture methods cultures of ***B. alvei*** which sporated promptly on nutrient agar were modified so that no spores were produced when cultured on the same mediums.

Cultures of a coccoid isolated from larvae sick of European foulbrood occasionally gave rise, after several generations, to rods and spores of *B. alvei*. By similar culture methods *B. para-alvei* was changed from sporogenic to asporogenic rods. Cultures of a coccoid isolated from larvae sick of parafoulbrood occasionally gave rise to rods and spores of *B. para-alvei*. Sporogenic cultures of *B. para-alvei* gave rise to two coccoid types. One of these was indistinguishable morphologically from cultures which were isolated from larvae sick of parafoulbrood. *Bacillus para-alvei* is described.

7. A Preliminary Report on the Feasibility of Treating Colonies Affected with American Foulbrood (*Bacillus larvae*). W. E. Dunham and P. E. King, Columbus, Ohio.

The results of investigations covering two seasons are given on treating colonies of honey bees affected with American foulbrood together with a bacteriological verification.

8. Some Aspects of Apiculture in the Past and Future. Prof. Herbert Osborn, Columbus, Ohio.

A brief reference to some of the early American workers in apiculture. The lives of investigators that have been followed with suggestions of possible phases in research desirable in the future.

9. Biometrical Studiés on *Apis florea* F. Claude R. Kellogg, Amherst, Mass.

Biometrical measurements were made upon preserved specimens of *Apis florea* Fabr., from South India with the aid of a micrometer eye-piece. The body length, submentum, mentum, length of right forewing, width of right forewing, and number of hooks on the right hind wing all showed variation in individual bees, but the means of these measurements are so constant that they may be used in the determination of the species.

10. The Variation in Weight per Gallon of Honeys from Different Floral Sources. George E. Marvin, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

The weight per gallon of 40 honeys of various floral sources obtained from different parts of the country was determined by direct weighing and by the refractometer. A considerable variation was found in the weight of these honeys. This variation applied not only to honeys of different floral sources, but also to honeys of the same floral source but from different localities and even in some cases to honeys of the same locality. Honeys produced in regions of high humidity weighed less than those from dry, irrigated sections.

The weight of the 40 honeys varied from 11.69 to 11.99 pounds per gallon. By direct weighing, not one sample weighed as much as 12 pounds per gallon, the figure which up to this time has been considered the minimum weight per gallon for a well-ripened honey. This study of 40 samples substantiates the decision, based on experiments covering a longer period, to place the minimum weight specification in the U. S. Grades for honey at 11.75 pounds per gallon of 231 cubic inches.

11. The Relation Between Number of Ovarioles and Size in Queen Honey Bee. J. E. Eckert, Davis, Calif.

12. The Use of Thermocouples in the Determination of Relative Humidity. A. W. Woodrow, Ithaca, N. Y.

Difficulty is often encountered in biological work in the measurement of relative humidity in small containers. A method is described which may be used when ordinary methods of meteorology are inconvenient or unsatisfactory.

13. The Effect of Colony Size on the Flight Rates of Bees. A. W. Woodrow, Ithaca, N. Y.

This is an account of further work on the previously reported subject of the comparative value of different colonies of bees in fruit pollination. Information obtained during the pollination seasons of 1932 and 1933 is included.

Report of Committees.

Selection of Officers.

Adjournment.

Program

Wednesday Evening Session, December 27, 7:30 P.M. Hotel Bradford, Parlor C

SECTION OF EXTENSION

H. E. HODGKISS, *Chairman* M. P. JONES, *Secretary*

Symposium: Dissemination of Entomological Information.

1. Problems of the Extension Entomologist. H. E. Hodgkiss. State College, Pa.
2. Methods of Conducting Extension Work. C R. Crosby, Ithaca, N. Y.
3. Extension Activities in the Entomological Program for Delaware. L. A. Stearns, Newark, Delaware.
4. Aims and Purposes of Extension Entomology. A. B. Graham, Washington, D. C.
5. Discussion of Papers.
6. Why Insect Control Practices Fail. Extension Entomologists, State College, Pa.
7. Popularizing Entomology. Bristow Adams, Ithaca, N. Y.
8. Procedures Responsible for Minnesota's Successful Grasshopper Control Campaign. T. L. Aamodt, St. Paul, Minnesota.

Selection of Officers.

Adjournment.

Program

Thursday Morning Session, December 28, 9:30 A.M. Austin Hall, Harvard University, Middle Hall

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Report of the Secretary.

Report of the Executive Committee by President W E Hinds.

Report of the Representative to the National Research Council, by W. A. Riley, St. Paul, Minn.

Report of the Governors of the Crop Protection Institute, by W. C O'Kane, Durham, N H

Report of Scientific Trustee, Tropical Plant Research Foundation, by Herbert Osborn, Columbus, Ohio

Report of the Representative on the Council of the Union of Biological Societies, by C. R. Crosby, Ithaca, N Y

Report of the Committee on Nomenclature, by J A Hyslop, Washington, D. C.

Report of the Committee on Endowment, by V. I Safro, West Nyack, N. Y.

Report of the Board of Trustees for Permanent Fund, by A I Bourne, Amherst, Mass.

Report of the Committee on Insect Collections, by J J Davis, Lafayette, Indiana.

Report of the Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints, by B A Porter, Washington, D. C

Report of the Committee on Research Work on the Control of the European Corn Borer, by G. A. Dean, Manhattan, Kansas

Report of the Committee on Training of Entomologists, by C. J Drake, Ames, Iowa.

Report of the Sub-committee on Entomological Exhibits for the Chicago Century of Progress Exposition, by W. P. Flint, Urbana, Illinois.

Report of Special Committee on Policy of the Journal of Economic Entomology, by H. J. Quayle, Riverside, California.

Report of Special Committee on Joint Meeting with the Entomological Society of America in Chicago, by W. P. Flint, Urbana, Illinois.

Report of Special Committee for Investigation of Reorganization of Entomological Research in the Federal Government, by E. F. Phillips, Ithaca, N. Y.

Appointment of Committees.

Miscellaneous Business.
New Business.
Annual Address of the President, W. E. Hinds, Baton Rouge, La.
1. Some Achievements in Economic Entomology.

Program

Thursday Afternoon Session, December 28, 1:30 P.M. Austin Hall, Harvard University, Middle Hall

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

2. What Shall be the Objective in the Training of an Entomologist. (5 min.) Dwight M. DeLong, Columbus, Ohio. (Lantern).

3. Some Queries Concerning Research Methods and Equipment. (5 min.) (Lantern). Alvah Peterson, Columbus, Ohio.

Some preliminary studies of materials used in constructing apparatus, etc.

4. On the Hereditary Ability of Certain Insects to Transmit Diseases and Diseaselike Injuries of Plants. (5 min.) (Lantern) F. W. Poos and Nancy H. Wheeler, Rosslyn, Virginia.

Discusses the disease-like injury caused by *Empoasca fabae* (Harris) and the blight of spinach transmitted by aphids.

5. Probable Effect of Regulated Production on Insect Abundance on Corn. (5 min.) J. H. Bigger, Jacksonville, Ill.

Studies of the effect of rotations on insect abundance in corn for the past five years have shown that where a rapid rotation is carried out and where the corn crop is immediately preceded by a legume from 53.2 to 80.5% of the corn will be free from insect damage by those insects which attack the underground portion of the plant.

6. The Chemical Constants of the Fats of Hibernating *Carpocapsa pomonella* and *Leptinotarsa decemlineata*. (5 min.) (Lantern). David E. Fink, Takoma Park, Md.

The paper deals with the chemical constants of the fats, of the saturated and unsaturated fatty acids, and of the soluble and insoluble acids of the fats determined every other week during the period of hibernation.

7. Observations on the Recent Outbreak of Encephalitis in Columbia, Missouri and a Study of the Possible Insect Carriers. (5 min.) Leonard Haseman, Columbia, Missouri.

Includes a brief history of each case and condition surrounding each, their distribution in the city together with a report on the possible insect carriers which were most prominent before and during the outbreak.

8. Preliminary Studies on Biological Control of *Pseudococcus brevipes* (Ckl.) (5 min.) Walter Carter, Honolulu, Hawaii.

Observations made in Jamaica and Central America reveal an extreme paucity of parasitism of *P. brevipes* and other species of mealy bugs on pineapple. Predator complexes offer some promise but are limited on account of minimum hóst-population requirements. Factors involved in biological control of disease-transmitting insects in general and of *P. brevipes* in particular are considered.

9. Technique Employed in Distributing *Thripoctenus brui* Vuillet in the Hawaiian Islands. (5 min.) Carl T. Schmidt, Honolulu, Hawaii.

A description is given of methods of reception and handling of the parasite, *Thripoctenus brui* Vuillet, introduced to the Hawaiian Islands for the purpose of controlling the onion thrips, *Thrips tabaci* Lind., the insect vector of "Yellow-spot" a virus disease of pineapple.

10. Hallucinations of Insects Causing Annoyance to Man. (5 min) Roger C. Smith, Manhattan, Kansas.

A brief account of two cases of hallucination of insect attack with a discussion of the relation of memory, suggestion and certain drugs to this problem.

Insects Affecting Field, Cereal and Forage Crops

11. The Green June Beetle in Lawns. (5 min.) W. A. Price, Lexington, Kentucky.

Method used to clear the lawn of grubs.

12. Strains of Corn Resistant to the European Corn Borer. (5 min) (Lantern). L. H. Patch, Toledo, Ohio.

One resistant inbred strain of corn transmits characters to the hybrids in which it enters, inhibiting the survival of about one-half the number of corn borers that would normally survive on the susceptible varieties and hybrids of corn.

13. The European Corn Borer in Connecticut During 1933. (5 min) (Lantern). J. Peter Johnson, New Haven, Conn.

An account of the commercial damage to sweet and seed corn as obtained in the field and from growers together with a summary of the annual fall borer population survey.

14. The History of the European Corn Borer (*Pyrausta nubilalis* Hubn.) on Long Island, New York. (5 min.) (Lantern). S. M. Dohanian, Arlington, Mass.

A brief history and the present status of the European Corn Borer on Long Island, N. Y. are presented.

15. Experimental Results Obtained in the Use of Ammonium Sulpho-soap with Nicotine Insecticides Against the European Corn-borer.

(5 min.) (Lantern). C. H. Batchelder and D. D. Questel, Arlington, Mass.

Nicotine insecticides with ammonium sulpho soap as a surface-tension depressant were used on dahlia and corn infested by the European corn-borer.

16. Comparative Effectiveness of Stalk-harvesting Methods in the 2-Generation Area of European Corn-borer Infestation. (5 min.) (Lantern). C H. Batchelder and D. D. Questel.

Results of 1933 experiment plot tests of silage harvesting methods in relation to infestation of corn by the European corn-borer

17. Subfreezing Temperatures Lethal to the European Corn-borer Infesting Green Ears of Sweet-corn. (5 min.) (Lantern) C. H. Batchelder and D. D Questel, Arlington, Mass

Methods of freezing green sweet-corn found necessary to insure safety from spread of the European corn-borer into uninfested territory

18. Additional Results on the Reactions of Corn Earworm Moths to Several Sugars (5 min) (Lantern) L. P Ditman and R. A. Littleford, College Park, Md.

Results of experiments to determine the relative attractiveness of sucrose, fructose and invert sugar to corn earworm moths

19. Recent Additions to Our Knowledge of the Life History of the Pea Weevil. (5 min) A. O Larson, T. A. Brindley, Frank G. Hinman, Corvallis, Oregon

New information has been obtained in regard to the method of hibernation quarters Some adult pea weevils live more than one year The weevils may oviposit the same summer that they develop or over a period of at least two more summers. One weevil may lay more than 700 eggs. Feeding punctures made by adult pea weevils may cause deformed pods in some varieties of peas.

20. Barium Fluosilicate in Blister Beetle and Cabbage Worm Control. (5 min.). H. F. Dietz and E. E. Zeisert, Wooster, Ohio.

Three years experiments with barium fluosilicate (Dutox) dusts show that this material meets the requirements of an effective, inexpensive control for blister beetles on vegetable and ornamental plants. Where standard arsenical sprays and dusts failed to control heavy infestations of cabbage worms, during the past season, barium fluosilicate dusts were very effective.

21. Seed Treatments for the Control of Root Maggots. (5 min.) (Lantern). Hugh Glasgow, Geneva, N. Y.

This paper discusses the effects of certain insecticides applied to the seed in preventing root maggot injury.

22. Ground Derris Root for Control of Cabbage Maggot. (5 min.) Robert C. Burdette, New Brunswick, N. J.

23. Field Studies of *Thrips tabaci* Lind. with Especial Reference to Resistance in Onions. (5 min.). Stanley F. Bailey, Davis, Calif.

Field studies of the onion thrips which establish the significant resistance of the White Persian variety.

24. Recent Experiments in the Control of the Onion Thrips. (5 min.) (Lantern). J. P. Sleesman, Ada, Ohio.

25. A Progress Report on the Control of the Potato Psyllid *Paratrioza cockerelli* Sulc. and Psyllid Yellows Caused by Its Feeding. (5 min.) George M. List and Leslie B. Daniels, Fort Collins, Colorado

"Psylled Yellows" which is one of the most important potato problems in the West has a definite response to the use of certain spray materials.

26. Further Investigations Regarding the Morbid Histology of "Psyllid Yellows". (5 min.) (Lantern). J. R. Eyer, State College, New Mexico.

Further studies of the histology of the normal potato plant as compared with that of plants affected with "Psyllid Yellows" corroborated the findings of past seasons and showed conclusively that the psyllid nymphs, when feeding normally on the leaves in the field, extract their nourishment largely from the border parenchyma surrounding the vacular bundles. This feeding apparently interferes with translocation at inception and typical chlorotic symptoms follow. No necrosis of any of the tissues other than those at the point of actual feeding was observed. Furthermore, there is no wholesale destruction or mechanical plugging of the vacular tissues. Microchemical studies of the stylet sheath (e.g. the path which the beak traverses in its entrance into the plant tissues) showed that it is largely intercellular although occasionally the stylets pierce individual cells while being forced into the parenchyma. Pectic materials in the cell walls are dissolved, mucin occurs in the stylet sheath, but no extensive suberization or cutinization results in the tissues where feeding occurs. Cells having been penetrated by the beak collapse and become filled with disintegrated granular protoplasm. A comparison of healthy and diseased petiole and stem tissues showed that there are significant differences in the synthesis of starch in plants affected with "Psyllid Yellows." Abnormally heavy starch deposits occur in the cortex and pith while starch is almost invariably absent in the endodermis and starch sheath where it normally occurs in the stems and petioles of healthy plants.

27. The Effect of Alfalfa Cutting Schedules Upon the Occurrence of Alfalfa Leafhoppers and Alfalfa Yellows in Wisconsin. (5 min.) E. M. Searles, Madison, Wisconsin.

28. The Use of Oil in Grasshopper Baits. (5 min.) J. R. Parker, R. L. Shotwell and F. A. Morton, Bozeman, Montana.

29. Injury to Heads of Grasses by Grasshoppers. (5 min.) Donald A. Wilbur, Manhattan, Kansas.

30. Result of Three Years Work Against Grasshoppers in Minnesota. (5 min.) A. G Ruggles, St. Paul, Minn

31. Observations on the Seasonal Activities of Wire Worms (Elateridae). (5 min) Harry R. Bryson, Manhattan, Kansas.

Results of observations made on the seasonal activities of wireworms at Manhattan, Kansas in connection with field studies, rearings, and ecological studies.

32. The Importance and Distribution of Phyllophaga spp. in Wisconsin During 1933 (5 min) P. O Ritcher and C L Fluke, Madison, Wisc.

Flight of Brood "B" small but widespread Twelve of the twenty-one species of June beetles known to occur in Wisconsin collected this year on food plants, at baits, and at lights Grub damage by broods "A" and "C" severe, many pastures totally ruined.

33 Subterranean Movements of White Grubs in Wisconsin and Their Relation to Farm Practices (5 min) C L Fluke and P O Ritcher, Madison, Wisconsin

Weekly diggings of white grubs indicate errors in past recommendations for grub control by farm practices

34. Life History and Control of the Potato Flea-Beetle *Epitrix cucumeris* Harris, in Eastern Virginia (5 min) (Lantern) Lauren D. Anderson, Norfolk, Virginia

The Potato Flea Beetle, *Epitrix cucumeris* Harris, is a problem of outstanding importance to Irish potato growers of Eastern Virginia. The adults feed on the foliage from its first appearance until the vines are dead, causing a premature dying of plants and reduction in yield At the same time the larvae feed upon the tubers causing a rough, pitted potato of inferior quality. Thirty different materials were used in the control project, the better materials giving an increase of 88 bushels of U. S. No. 1 potatoes per acre over the checks.

35. Studies of Millipeds and Gnat Injuries to Potato Tubers. (5 min.) (Lantern). G. F. MacLeod and F. G. Butcher, Ithaca, N. Y.

Results of experiments with sulphur and naphthalene for the control of millipeds and gnats on potatoes.

36. Experimental Studies of the Wheat Wireworm, *Agriotes mancus* Say. (5 min.) (Lantern). W. A. Rawlins, Ithaca, N. Y.

Ecological studies for the control of wireworms.

37. The Use of Naphthalene for the Control of Onion Thrips. (5 min.) (Lantern). F. B. Maughan, Ithaca, N. Y.

Results obtained using naphthalene alone and in combination with dust carriers.

38. Potato Spraying and Dusting Experiments on Long Island. (5 min.) (Lantern). Henry Menusan, Ithaca, N. Y.

Decreases in yields of potatoes obtained with Bordeaux sprays.

39. The Effects of Potato Sprays on Larval Feeding of Flea Beetles on Tubers. (5 min.) (Lantern). D. O. Wolfenbarger, Ithaca, N. Y.

Variable results showing little or no correlation between spraying practices and larval potato flea beetles.

40. Chinch Bug Resistance in Corn—An Inherited Factor. (5 min.) (Lantern). J. R. Holbert and W. P. Flint, Urbana, Ill.

During the past year work carried on at Bloomington, Illinois with a number of inbred strains of corn and crosses of such corns has shown very conclusively that certain strains carried chinch bug resistance, or susceptibility to chinch bug injury as a dominant factor. It has also been shown that certain other strains which are either resistant or susceptible in themselves do not carry such qualities as dominant inherited factors. Further data are also presented showing the degree of susceptibility or resistance in certain varieties of corn adapted to the central and north central parts of the corn belt.

Program

Thursday Afternoon Session, December 28, 1:30 P. M. Austin Hall, Harvard University, West Hall

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

41. Dutch Elm Disease Control and the Elm Bark Borer (5 min.) E. P. Felt, Stamford, Conn.

The recognition of the European elm bark beetle as an important and possibly the principal carrier of the Dutch elm disease and present conditions make the control of this insect a problem of major importance. The discovery of imported elm logs infected with the disease and infested with this beetle goes far to establish the origin of the American infections. The elm bark beetle is restricted in its breeding largely to sickly and dying wood, and since it is the presumably important carrier of the disease, it is desirable to reduce the breeding of this insect. The systematic cutting out and burning of sickly or dying trees or parts of trees is a practical measure, since general tree sanitation produces conditions unfavorable to this Dutch elm disease carrier. It is also good tree practice and can be recommended for communities distant from any known infection. Repeated defoliations by insects justify a comprehensive spray program in order to maintain tree vigor and lessen the amount of sickly and dying wood. Weak trees should either be summarily removed or treated to restore vigor. The threat of the Dutch elm disease abundantly justifies a policy of control and possible eradication.

42. Exploring Upper Air for Wind-borne Gipsy Moth Larvae. (5 min.) (Lantern). C. W. Collins and W L. Baker, Melrose Highlands.

43 Notes on the Beech Scale (*Cryptococcus fagi* Baer.) in New England. (5 min.). (Lantern). R. C. Brown, Melrose Highlands, Mass.

44. Control of the European Pine Shoot Moth by Spraying. (5 min.) (Lantern) R B. Friend and A. S. West, Jr., New Haven, Conn.

A lead arsenate fish oil mixture has given excellent results.

45. The Control of the Willow Snout Beetle (*Orchestes rufipes*) in Maine. (5 min.) H. B. Peirson and Robley W. Nash, Augusta, Maine.

46. Some Observations on the Fir Bark Louse (*Dreyfusia picea* Ratz.) in Maine (5 min) (Lantern). H. B. Peirson and Arthur M. Gillespie, Bar Harbor, Maine.

47. Predatory Checks, Especially Birds, on the Birch Leaf-mining Sawfly, *Phyllotoma nemorata* Fall. (5 min) (Lantern). A. E. Brower, Bar Harbor, Maine.

When this European insect became epidemic in Maine, the percentage of destruction by birds was found to be small, but it has constantly increased. Birds have not been found destroying the native leaf-miners.

48. A New Mite on Boxwood (*Neotetranychus buxi* n. Sp. Garman). (5 min.) (Lantern). Donald T. Ries, Bloomfield Hills, Mich.

A biological study of mite as recorded in Oakland County, Michigan.

49. Insect Work in Civilian Conservation Corps Camps in Connecticut. Control Measures Taken Against White Pine Weevil and European Pine Shoot Moth. (5 min) George H. Plumb and Henry W. Hicock, New Haven, Conn.

Insects Affecting Deciduous Fruits

50. Codling Moth Activity as Indicated by Phototropic Response. (5 min.) (Lantern). P. J. Parrott and Donald L. Collins, Geneva, N. Y.

Seasonal history of codling moth as shown by captures at lights compared with records from emergence cages and with captures in bait pails. Records relative to flights of stained moths.

51. Occurrence of *Ascogaster carpocapsae* in Illuminated and Sprayed Areas of an Apple Orchard. (5 min.) (Lantern). P. J. Parrott and Donald L. Collins, Geneva, New York.

The occurrence of cocoons and adults of *A. carpocapsae* in relation to the host population in differently treated areas of an apple orchard.

52. Further Results With Codling Moth Bands in Pennsylvania. (5 min.) (Lantern). Harlan N. Worthley, State College, Pa.

Attractiveness and killing power of different types of band. Data on cost and effectiveness of banding operation.

53. Some Results Secured with Supplementary Control Measures for the Codling Moth. (5 min.) Leonard Haseman and George D. Jones, Columbia, Missouri.

Results secured where codling moth populations were very high by using light and heavy spray schedules both with and without supplementary control measures.

54. The Apple Leaf-Curling Midge, A New Pest of Apples. (5 min.) (Lantern). W. D. Whitcomb, Waltham, Mass.

Dasyneura mali Kieffer, which rolls the leaves of terminal shoots and water sprouts on apple, is now well established in northeastern Massachusetts and southeastern New Hampshire and its distribution, habits, life history, as well as the injury which it causes are discussed.

55. Notes on Control of the White Apple Leafhopper in Connecticut. (5 min.) (Lantern). Philip Garman, New Haven, Conn.

Summary of field control work with this insect since 1931 at the Conn. Agric. Exp. Station.

56. Some Observations on Long Distance Dispersal of Apple Maggot Flies. (5 min.) (Lantern). A. I. Bourne, Amherst, Mass.

Attempts to discover the limits of probable dispersal of Apple Maggot flies, by releasing marked flies at distances of 400 to 600 yards from bearing trees.

57. Sixth Contribution to a Study of Baits With Special Reference to Oriental Fruit Moth. (5 min.) G. W. Frost, Arendtsville, Pa.

Tests with numerous chemicals are summarized. Special emphasis is placed on other insects which are attracted by baits and interfere with the effectiveness of the baits.

58. Methods of Determining the Degree of Parasitism of Twig-Infesting Oriental Fruit Moth Larvae. (5 min.) H G. Butler, Harriman, Tenn.

A brief discussion of the three methods used in 1930 and 1931, 1932, and 1933 respectively. A comparison of data so taken in 1933 as to permit assembling in two ways, shows that a difference of 8 per cent, 20 per cent and 25 per cent in the degrees of parasitism, as determined by the two methods, exists in the records of June, July and August respectively. The results of a single, separate, different test of the basic idea show a difference of 22 per cent in the degree of parasitism found in larvae collected at the same tine in the same orchard. The method used, while both logical and simple, is not known to the writer to have been previously reported

59. Results of Further Experiments With a New Method for the Control of the Peach Borer, *Aegeria exitiosa*, with Special Application to Nursery Stock. (5 min.) (Lantern). Oliver I. Snapp, Fort Valley, Georgia.

This paper gives the results of experiments with emulsions of oils impregnated with para-dichlorobenzene and applied as sprays for the control of the peach

borer. The method is the only safe and effective one known for the control of the insect in nursery stock and young peach trees.

60 A Progress Report on the Control of the Cherry Case Bearer (*Coleophora pruniella* Clem.) in Wisconsin. (5 min.) J. H. Lilly and Charles L. Fluke, Jr. Madison, Wisconsin.

The various materials used are compared as to insect kill and tree injuries. The importance of concentrations used, value of certain supplementary materials, relation of temperature and time of application to effectiveness, and the importance of thorough spraying are also discussed.

61. Observations on the Habits and Control of *Glossonotus crataegi* (Membracidae), on Plum and Apple. (5 min.) Ray Hutson, East Lansing, Mich.

62. "*Phylloxera devastatrix* Perg on Pecans". An Account of the Seasonal History, Habits, and Methods of Control of *P. devastatrix* on Pecans is Given. (5 min.) Howard Baker, Marshfield, Mass.

63 Experiments with Kerosene Against the Apple Curculio. (5 min.) (Lantern). Oscar H Hammer, Geneva, N. Y.

The effect of various strengths of kerosene emulsions on the hibernating and immature forms of the apple curculio are discussed.

Program

Friday Morning Session, December 29, 9:30 A. M. Austin Hall, Harvard University, Middle Hall

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

Insecticides

64. Foliage Injury Caused by Arsenicals and Bordeaux Mixture. (5 min.) S. F. Potts, Melrose Highlands, Mass.

65. Dairy Fly Sprays. (5 min.) (Lantern). Stanley B. Freeborn, Davis, California.

A resume of eight years' work including new data on their efficiency and effect on the dairy cow.

66. The Relative Value of Bordeaux, Sulphur and Pyrethrum Products in Reducing Populations of Potato Leafhopper. (5 min.) (Lantern). Dwight M. DeLong, Columbus, Ohio.

Graphs will be shown to indicate the natural populations in the field and the type and percentage of reduction in populations obtained by these materials. The "residual" value of Bordeaux and sulphur is shown.

67. Pyrethrum Dusts on Cranberry Bogs. (5 min.) (Lantern). E. Avery Richmond, Brockton, Mass.

A general review of results obtained by the use of pyrethrum dust mixtures for the control of cranberry insects, occurring on the bogs of southeastern Massachusetts, during 1931–1933 inclusive.

68. Preliminary Report on the Insecticidal Action Against Thrips of Derris, Nicotine, Paris Green and Other Poisons in Combination with Molasses. (5 min.) (Lantern). H. H. Richardson, Washington, D. C.

Laboratory and greenhouse studies on the toxicity toward thrips of nicotine sulphate, derris extract, hellebore, pyrethrum, Paris green and other insect poisons in combination with molasses are reported. The importance of a toxic and stable spray deposit in contrast to strong contact action for thrips control is discussed. Tests on the stability to sunlight of the deposits left by various derris sprays are also reported.

69. Notes on the Use of Derris and Pyrethrum Dusts for the Control of Certain Insects Attacking Cruciferous Crops. (5 min.) (Lantern). Harry G. Walker and L. D. Anderson, Norfolk, Virginia.

This is a report on the use of different strengths of Derris and Pyrethrum dusts for the control of the cabbage looper *Autographa brassicae* Riley, the larvae of the diamond backed moth *Plutella maculipennis* Curt., and the Harlequin bug *Murgantia histrionica* Hahn. The results obtained with Derris dust used in combination with the following inert carriers, gypsum, talc, lime, flour, clay, tobacco dust, and a zinc sulphate-lime mixture for the control of these three insects are also given.

70. Insecticidal Properties of Completely Extracted Derris Root Residue. (5 min.) Lantern). Joseph M. Ginsburg and Philip Granett, New Brunswick, N. J.

Residues from derris root extracted with acetone possess toxicity and repellency to cabbage worms and silk moth caterpillars, but no toxicity to aphis. Residue from derris root extracted first with acetone and then with water has shown no direct toxicity to chewing insects but still possessed strong repellent and deterrent properties.

71. Recent Developments in Oil Sprays. (5 min.) Hugh Knight and C. R. Cleveland, Claremont, California and Chicago, Illinois.

Internal oil soluble emulsifiers comprising certain glycerides of the fatty acids, not only give excellent emulsions for spraying purposes, but also change the physical characteristics of petroleum oil so as to retard penetration into plant tissue and maintain surface films for greatly extended periods of time. These can be regulated by varying the proportions of the oil soluble emulsifier. By the use of these materials there are indications that the field of usefulness of oil sprays may be greatly extended so as to include a materially improved control of Codling Moth and allied insect pests. Examples of some preliminary

field tests against scale infesting citrus, codling moth on apples, and pear psylla, on pears, are given.

72. Further Studies on the Oil-Depositing Property of Oil Sprays. (5 min.) R. H. Smith and J. P. LaDue, Riverside, Calif.

73. The Synergistic Effect of the Chlorides and Bicarbonides of Potassium and Sodium, upon the Paralytic Action of Nicotine in the Cockroach. (5 min.) N. D. Levine and C. H. Richardson, Ames, Iowa.

74. Halowax As a Contact Insecticide. (5 min.) E. P. Breakey, Columbus, Ohio.

A summary of studies relative to the use of Halowax, a chlorinated naphthalene product, as a contact insecticide.

75. Role of Some Southern Pine Products in Control of *Aphis rumicis*. (5 min.) C. O. Eddy, Lexington, Ky.

76. Notes on Paradichlorobenzene, Naphthalene and the Cedar Oils as Repellents Against Clothes Moth Adults. (5 min.) (Lantern). Samuel C. Billings, Silver Spring, Md.

Adult clothes moths freely laid their eggs on pieces of flannel that had been placed in the vapors of the various substances listed in the title. The resulting larvae fed freely. Pictures of the five pieces of flannel will be shown in the lantern. The purpose of this article is to establish that these materials are not clothes moth repellents.

77. A New Non-inflammable, Non-explosive Fumigant. (5 min.) R. M. Jones, Mountain Grove, Missouri.

78. A Review of Pyrethrum as an Agricultural Insecticide. (5 min.) Alfred Weed and M. D. Leonard, New York, N. Y.

A brief resume of the history, development and present uses of pyrethrum for the control of insects injurious to plants. Suggestions are made for future lines of work and references to the more important sources of information are cited.

79. Some Effects of the Vapor of Ethylene Oxide on the Bean Weevil and the Confused Flour Beetle. (5 min.) (Lantern). William R. Horsfall, Monticello, Arkansas.

With concentrations of the gas below that causing death and with very short exposures several parts of the different stages were found to be affected.

Spray Residue and Lead Arsenate Substitutes

80. Some Results Secured with Supplementary Control Measures for the Codling Moth. (5 min.) Leonard Haseman and George D. Jones, Columbia, Missouri.

Results secured where codling moth populations were very high by using light and heavy spray schedules both with and without supplementary control measures.

81. Arsenic Deposit and Codling Moth Control. (5 min.) (Lantern) R. L. Webster, Pullman, Wash.

High deposits of lead arsenate have been necessary to check the codling moth in the Pacific Northwest. Deposits have been increased by the use of fish oil, mineral oil, and colloidal spreader. Difficulty in residue removal has occurred following certain combination sprays.

82. Effects on Apple Foliage of Different Arsenicals and Fungicides in Combination. (5 min.) (Lantern) C. R. Cutright, Wooster, Ohio.

Five arsenicals and five fungicides were used in 25 combinations to determine their various effects on apple foliage. As the experiment progressed defoliation seemed to be the outstanding feature in the performance of certain of the combinations and a special method of taking such records was developed. A brief description of this method together with the data so collected is presented.

83. Some Comparisons Between Calcium Arsenate and Lead Arsenate as General Insecticides of Apple. (5 min.) (Lantern) P. J. Chapman, G. W. Pearce, R. W. Dean and O. H. Hammer, Geneva, N. Y.

Field and laboratory data are given on differences found among several commercial calcium arsenates and on the behavior of this material in various combinations as regards safety to the host and toxicity to the more important apple pests.

84. Comparative Tests of Arsenicals, Arsenicals with Oil and Several Nicotine Compounds Used Against the Codling Moth. (5 min.) (Lantern) Byrley F. Driggers, New Brunswick, N. J.

85. Lead Arsenate Substitutes for Codling Moth Control. (5 min.) James Marshall, Wenatchee, Washington.

Calcium arsenate, manganese arsenate, zinc arsenate, and zinc arsenate applied in combination with animal, vegetable, and mineral oils have resulted in widely varying degrees of codling moth control and foliage and fruit injury following tests in the Wenatchee Valley, Washington. Certain combinations of these materials have given results comparable to lead arsenate used alone

Program

Friday Afternoon Session, December 29, 1:30 P. M. Austin Hall, Harvard University, Middle Hall

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Symposium on the Spray Residue Problem

Discussion Under the Direction of P. J. Parrott, Geneva, N. Y.

Control of Interstate Traffic in Sprayed Fruits and Vegetables during the Current Season, by W. B. White of the Food and Drug Administration, Washington, D. C.

The Status of Codling Moth Control with Insecticides. R. L. Webster (12 min.)

Three Minute Discussions of Regional Aspects of the Problem

E. J. Newcomer
W. P. Flint
S. W. Harman
W. S. Hough

To What Extent May Organic Insecticides be Used as Substitutes for Arsenicals. T. J. Headlee (12 min.)

The Situation in the Vegetable Industry with Respect to the Use of Arsenicals and Arsenical Substitutes. W. H. White (12 min.) H. C. Huckett (12 min.)

Latest Developments in Spray Residue Removal. H. C. Robinson (12 min.) H. C. McLean and Albert Weber (12 min.)

Program

Friday Evening Session, December 29, 7:30 P. M. Austin Hall, Harvard University, Middle Hall

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Final Business

Report of the Committee on Resolutions
Report of the Committee on Membership
Report of Other Committees.
Nomination of Journal Officers by Advisory Committee
Report of Committee on Nominations.
Election of Officers.
Miscellaneous Business.
Fixing time and place of next Annual Meeting.
Final Adjournment.

W. E. HINDS, *President*,
Baton Rouge, La.

A. I. BOURNE, *Secretary*
Amherst, Mass.

JOURNAL
OF
ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 26 FEBRUARY, 1933 No. 1

The Proceedings of the Forty-Fifth Annual Meeting of the American Association of Economic Entomologists

The 45th annual meeting of the American Association of Economic Entomologists was held in the Haddon Hall Hotel, Atlantic City, December 28-30, 1932, with an attendance of approximately 175 members and visitors

The opening day was devoted to the program of the Section of Plant Quarantine and Inspection which continued through morning and afternoon sessions

On Thursday morning December 29, the program of the Main Association opened with the transaction of routine business and the Address of the President, on the subject "Balancing the Entomological Program." The afternoon was devoted to the presentation of Papers. The Section of Apiculture held its meeting during Thursday afternoon

Friday morning, December 30, was devoted to a joint session with the Eastern Branch, one-half of the program supplied by members of that branch and the remainder to the presentation of invitation papers prepared by Messrs. Parrott, Flint, Ackerman and List

The Main Association continued the reading of papers throughout Friday afternoon and completed the program at an evening meeting. At the close of this session, the final business meeting was held and the 45th Annual Meeting adjourned at 10 P. M.

It was voted to hold the next Annual Meeting in conjunction with that of the American Association for the Advancement of Science in Boston, Mass., December 1933.

The Entomologists Dinner was held in the Rutland Room of the Haddon Hall Hotel Thursday Evening, December 29th with an attendance of practically 100% of those present at the meetings. Under the direction of the toastmaster, Professor W. C. O'Kane, a very instructive and entertaining program was presented The evening proved

most enjoyable and was the subject of very favorable comment by all who attended.

Fifty new members were added to the membership of the Association and three reinstated.

Dr. W. E. Hinds of Baton Rouge, La , was elected President for the ensuing year.

PART I. BUSINESS PROCEEDINGS

The opening session of the 45th Annual Meeting of the American Association of Economic Entomologists convened on Thursday morning, December 29, 1932, at ten o'clock, at Haddon Hall Hotel, Atlantic City, New Jersey, W. P. Flint, President of the Association, presiding

President Flint: It is now my honor to open the 45th Annual Session of the American Association of Economic Entomologists

The first order of business on the program is the report of the Secretary.

REPORT OF THE SECRETARY

The total membership at the New Orleans Meeting was 1201, including 600 Active, 549 Associate and 52 Foreign members. This included 6 Life members.

The present membership (December 1) totals 1234 as follows Active members 618, Associate members 565, and 51 Foreign members This represents a net increase over the previous year of 34, the alterations being due to reinstatements, election to Associate membership, deaths, voluntary resignations and involuntary resignations for non-payment of dues. There are at the present time 12 Active and 43 Associate members who are subject to separation from the Association on January 1, 1933 for non-payment of dues.

The continued state of business depression has materially affected a considerable proportion of our membership and has been reflected in their relations with this Association, particularly those of a financial nature. This effect this year upon the finances of the Association has been appreciable and undoubtedly will be more noticeable another year if present conditions continue.

The records available show that since the preparation of the report last year 4 Active members and 1 Distinguished Foreign member have died.

Dr. George G. Atwood died on Sunday, December 6, 1931, at Clearwater, Florida. He was connected with the New York State Dept. of Agriculture and Markets from 1898 until 1927 when he reached the age limit for retirement. Shortly afterward he moved to Florida where he was residing at the time of his death. Previous to his long and distinguished association with the New York Dept. of Agriculture he conducted a large Nursery in Geneva, New York.

Dr. Arthur Mills Lea died February 29, 1932 at Adelaide, South Australia. He served for many years as Government Entomologist at Tasmania and held a similar post in Fiji. In 1911 he was appointed Government Entomologist of South Australia which position he held until his death.

In every field of Entomology which he entered he rendered service of a very high order. His work in Systematic Entomology was perhaps the most outstanding. Very few Entomologists have ever described so great a number of forms previously unrecognized.

The place he held in the estimation of his fellows is indicated by the statement of a contemporary that he was the greatest of the Australian born Entomologists.

Dr. Charles James Stewart Bethune died April 18, 1932 in his 94th year. His career was a distinguished one in many lines. He served for a brief period in the Ministry, later becoming headmaster in a leading boys school of Canada, a position which he held for many years. He was for 14 years at the head of the Department of Entomology and Zoology at the Ontario Agricultural College, retiring in 1920. He was very largely instrumental in the organization of the Entomology Society of Ontario and was several times elected its president. For nearly 30 years he served as editor of the Canadian Entomologist.

Throughout his life he had an active interest in Entomology. He was the author of many papers in both Systematic and Economic Entomology. His work commanded the attention and esteem of Entomologists throughout America, and also abroad His death marks the passing of one of the pioneers in Entomology.

Professor Anthony Spuler died May 30, 1932 in an accident on Lake Wenatchee, Washington, in which both he and his wife were drowned.

He received his entomological training in the State College of Washington, completing his undergraduate work in 1917 and receiving his Master's degree in 1919. As Assistant Entomologist in the Washington Experiment Station his work was chiefly along lines of fruit insect control. He developed the poison bait control for Strawberry Weevil. More recently his studies led to better timing of sprays for Codling Moth control, from the use of bait traps. A career of valuable achievement and of still greater promise was terminated when he was cut off in the midst of his usefulness.

Dr. W. J. Holland, director emeritus of the Carnegie Museum, died December 13 at his home in Pittsburg, after a brief illness. Dr Holland was in his eighty-fourth year.

A graduate of Amherst College in the Class of 1869, he received the degree of A. M. from that institution in 1872 He was also a graduate of Princeton Theological Seminary and the recipient of honorary degrees from many of the leading colleges and universities.

His travels were extensive and his interests varied. He was long recognized as a leading authority in the field of paleontology as well as zoology. He was the author of many papers, his monumental works on the Butterflies and Moths being regarded as among the classics of entomology

Dr. Holland received decorations from many foreign governments in recognition of the value of his work. He was one of the outstanding men of science of his generation

The Seventh Annual Meeting of the Cotton States Branch was held at Birmingham, Alabama, on February 3, 1932. The attendance was somewhat smaller than usual, probably due in part to the large number of members who attended the New Orleans Meeting of the Parent Association slightly more than a month previous. The following officers were elected: Chairman, J. W. Folsom, Tallulah, La.; Vice-Chairman, R. W. Leiby, Raleigh, N. C.; Secretary-Treasurer, O. I. Snapp, Fort Valley, Ga.

The Seventeenth Annual Meeting of the Pacific Slope Branch was held at Washington State College, Pullman, Washington, Thursday and Friday, June 16 and 17, 1932, with an attendance of approximately 40 Entomologists, with their families. President W. P. Flint was present and conveyed the greetings of the Parent Association. Arrangements were made for visits to the Entomology Department of the University of Idaho at Moscow and the Wire Worm Control Experiment Station at Walla Walla. The following officers were elected: Chairman, R. L. Webster, Pullman, Washington; Vice-Chairman, George I Reeves, Salt Lake City, Utah; Secretary-Treasurer, H. A. Scullen, Corvallis, Oregon.

Indices to the Literature of American Economic Entomology

Indices I and II:

Sales of these volumes during the past year have amounted to $35.00.

Index III:

The sales of this volume has yielded an income of $50 40.

Index IV:

The sales of this index has totalled $126.40.

There is an ample supply of all four volumes. The price has been held down to $5.00 a copy. It is hoped that as many of the members as find it possible will add this set in whole or in part to their personal or departmental libraries.

Journal of Economic Entomology

Volume 25 of the Journal of Economic Entomology just completed with the December number contains 1265 pages, somewhat smaller than Volume 24, but considerably in excess of any previous volume.

This increase in the size of the Journal has been made possible without increased rates, very largely by the prompt payment of their subscriptions by our members and other subscribers, notably our foreign subscribers; by funds derived from advertising, by sales of back numbers and payment by authors for papers in excess of six pages.

Complete sets of the Journal are still available with a few exceptions. No advances in prices was made this year. The limited supply of some of the volumes and separate numbers will undoubtedly make this necessary in a few cases.

The Journal is being mailed to every state and the Federal District, as well as more than 50 Foreign Countries. The geographical distribution of subscribers for the years 1913, 1923, 1931 and 1932 follows:

	1913	1923	1931	1932
Alabama	3	9	10	9
Arizona	7	8	22	25
Arkansas	2	4	7	7
California	34	67	154	159
Colorado	7	12	16	17
Connecticut	10	15	28	30
Delaware	3	3	8	8
District of Columbia	50	55	70	68
Florida	7	15	27	28
Georgia	6	10	22	22
Idaho	2	6	16	12
Illinois	30	31	40	42
Indiana	16	15	30	26
Iowa	5	12	20	29

Kansas	16	16	21	20
Kentucky	4	5	8	6
Louisiana	12	17	31	32
Maine	5	7	9	10
Maryland	11	14	29	31
Massachusetts	48	76	65	66
Michigan	15	10	27	25
Minnesota	10	14	21	20
Mississippi	4	22	36	36
Missouri	8	12	20	19
Montana	5	7	8	13
Nebraska	3	3	9	8
Nevada	1	2	3	3
New Hampshire	4	9	7	8
New Jersey	14	22	45	49
New Mexico	3	3	4	5
New York	52	69	93	103
North Carolina	6	8	21	19
North Dakota	0	1	2	1
Ohio	22	34	80	77
Oklahoma	2	5	8	9
Oregon	10	12	25	23
Pennsylvania	18	38	47	50
Rhode Island	3	7	4	4
South Carolina	4	2	10	11
South Dakota	1	2	3	3
Tennessee	6	11	21	18
Texas	16	21	58	62
Utah	8	9	19	19
Vermont	1	1	2	1
Virginia	7	16	23	28
Washington	8	8	26	35
West Virginia	5	5	7	5
Wisconsin	6	13	19	22
Wyoming	0	2	3	3
Total for U. S.	520	765	1294	1326
U. S. Insular Possessions and Cuba	26	—	—	—
Hawaii	—	11	20	18
Alaska and Panama	—	2	2	1
Philippine Islands	—	5	5	6
Porto Rico and Cuba	—	7	17	11
Canada	27	47	59	55
Foreign	132	183	362	362
GRAND TOTAL	705	1020	1759	1779

There is attached hereto a statement of the income received and disbursements made for the Association, Journal and Index Accounts, and a similar statement for the Permanent Fund. These were audited by E. L. Millington, State Auditor, Springfield, Mass.

Respectfully Submitted,
A. I. BOURNE,
Secretary

Upon motion regularly made and seconded, it was voted that the report of the Secretary be adopted.

Statement of Cash Receipts and Disbursements American Association of Economic Entomologists

For the period from November 18, 1931 to November 29, 1932

	Total	Journal	Association	Index IV	Index III	Index I and II
Balance, Nov. 18, 1931, per previous report	$5,751.22	$3,631.01	$1,493.11	$ .49	$ 4.71	$621.90
Income						
Sales	211.80			126.40	50.40	35.00
Subscriptions, advertising and miscellaneous	7,143.61	7,143.61				
Dues and separates	1,368.67		1,368.67			
Collection of returned checks	54.52		54.52			
	14,529.82	10,774.62	2,916.30	126.89	55.11	656.90
Expenses						
Printing	5,941.41	5,941.41				
Halftones and engraving	539.57	539.57				
Postage	183 87	105 07	73.35	3.57	1.10	.78
Supplies and stationery	46.19	12.19	34.00			
Telegraph, freight and express	30.68	23.14	7.54			
Editor	100.00	100.00				
Secretary salary	100.00	50.00	50.00			
Clerical work	272.01	161.70	110.31			
Transfer to permanent fund	1,000.00	250.00	750.00			
Stenographic report	149.38		149.38			
Auditing	50.00		50.00			
Surety bond for secretary	12.50		12.50			
Rental safe deposit box	5.50		5.50			
Branch secretaries expenses	53.13		53.13			
Federal check tax	.22		.22			
Association badges	18.74		18.74			
Back numbers	8.00	8.00				
Steel filing cabinet	21.00		21.00			
Refund on subscription	2 10	2.10				
Exchange charge on foreign checks	.47		47			
Checks returned	91.52		91.52			
Total expenses	8,626.29	7,193.18	1,427.66	3.57	1.10	.78
Balance, Nov. 29, 1932	$5,903.53	$3,581.44	$1,488.64	$123.32	$ 54.01	$656.12

The balance is on deposit at the:

First National Bank, Amherst, Mass.	$2,903.53
First National Bank, Malden, Mass.—Certificates of Deposit	3,000.00
	$5,903.53

Permanent Fund American Association of Economic Entomologists

For the period from November 18, 1931 to November 29, 1932

Balance, November 18, 1931, per previous report		$12,857.85
Additions		
Interest from securities	$ 546.25	
Interest from Savings Bank Deposits	64.57	
Interest from Index, Journal and Association accounts	123.15	
Transfer from Journal and Association accounts	1,000.00	1,733.97
		$14,951.82

Deduction			
Expended for premium on securities			57.54
Balance, November 29, 1932			$14,534.28
Invested as follows:			
Par value	Bonds		
1500	United States Liberty 4¼%	$1,500.00	
2000	Province of Ontario 5%	2,000.00	
4000	Federal Land Bank 4¼%	3,550.00	
5000	United States Liberty 4¼%	4,960.00	$12,010.00
Bank Deposits			
Savings Bank			
Amherst Savings Bank		$1,563.15	
Savings Department, Trust Company			
Franklin County Trust Company, Greenfield, Mass		961.13	2,524.28
			$14,534.28

Audit of the accounts of the American Association of Economic Entomologists covering period from November 15, 1931, to November 29, 1932.

Receipts as recorded in cash book verified.

Cancelled checks compared with recorded payments and vouchers examined.

Balance, per cash book, verified with statement from First National Bank, Amherst, Mass.

Income from Permanent Fund, and balance, as shown in report, verified by examination of bank books and securities.

Appended is a schedule of receipts and payments for the audit period showing cash balance in hands of the treasurer November 29, 1932, and a statement of the income during the period and condition of the Permanent Fund, November 29, 1932.

Springfield, Mass.
December 10, 1932

ERNEST L. MILLINGTON,
State Accountant

REPORT OF THE EXECUTIVE COMMITTEE

By a vote of the Executive Committee, it was decided to hold the meeting of the Association at Atlantic City in December, 1932. Because of the objections raised in numerous letters to the President of the Association, to this meeting place, a second vote of the Executive Committee was taken on April 9th. In addition to the Executive Committee, all Vice-Presidents of the Association were asked to express their opinion as to the desirability of meeting in Atlantic City in 1932. Only two votes were received in favor of other meeting places.

The Executive Committee has voted to accept the invitation of the Chicago Century of Progress Exposition to hold a summer session of the American Association of Economic Entomologists in Chicago in 1933. The exact date has not been set but will be given out as soon as final arrangements are made. Some thirty other scientific societies will also hold summer meetings in Chicago.

The President of the Association appointed T. J. Headlee and C. H. Hadley to make local arrangements for the meeting of the Association and asked them to appoint such other members as they desired to assist them.

As requested by the Executive Committee in 1931, the President appointed a committee to consider the future policy of the Journal of Economic Entomology.

The committee consists of W. B. Herms, Berkeley, California, Chairman; A. F. Burgess, D. M. DeLong, W. E. Hinds, and C. L. Metcalf.

The President of the Association appointed Dr. L. O. Howard and Dr. W. E. Hinds as official delegates from the American Association of Economic Entomologists to represent the Association at the Fifth International Congress of Entomology in Paris in 1932. Dr. W. H. Larrimer and Dr. Herbert Osborn were appointed alternates. Dr. Howard and Dr. Hinds represented the Association at the Congress and their report will be given later.

In response to a request from Brooklyn College, Dr. E. P. Felt was appointed to represent this Association at the inauguration of President Boylan of Brooklyn College in June.

In response to a request from F. E. Denny, Secretary of the Union of American Biological Societies, Dr. C. L. Melander was appointed to represent the association at the meeting of the Council of the Union of American Biological Societies at Atlantic City on December 27th, 1932.

The President of the Association attended the meeting of the Pacific Coast Branch of the Association at Pullman, Washington, on June 16 and 17. While the attendance at this meeting was not large, the interest was most excellent and a very fine program of papers was presented.

It was suggested by the Pacific Coast Branch that attendance at their meetings be considered one of the duties of the President of the Association. I am sure if future presidents have the same feeling as the retiring one that this will be a most pleasant and profitable duty.

The Executive Committee has acted upon the proposal of last year to make a careful study of the general activities of the Association and the need of formulating comprehensive plans for further development. In the course of this study, it has enlisted the services of various interested members, including the President and Secretary of the Entomological Society of America.

The Committee is of the opinion that the Association has reached a point in its growth where expansion of its activities is advisable, and that in the near future it will become necessary to arrange for a full time executive officer. In order to make this possible, it will be necessary to materially increase the Permanent Fund. The Committee feels an increase in the fees or annual dues of the members at the present time is inadvisable.

It is the opinion of the Committee that additional study of the activities of the Association is necessary and a further report will be made at the next annual meeting.

In their report to the Association at New Orleans, the Committee made the following statement. "Your Executive Committee realizes the present and potential future value of Biological Abstracts and since some of the other Societies have contributed to the support of this enterprise, it recommends that $100.00 be subscribed from the General fund of this Association, payments thereof being made when the Executive Committee is satisfied that the publication of Biological Abstracts is to be continued."

The Committee now feels assured of the continuance of this enterprise and has authorized the payment of the above amount.

A communication has been received from Dr. Fernandus Payne, Chairman, Division of Biology and Agriculture of the National Research Council relative to proposed reorganization of that body.

Your committee approves of the proposal submitted by the Chairman of the Di-

vision of Biology and Agriculture for representation of this Association on that Council.

W. P. FLINT

Upon motion regularly made and adopted, it was voted that the report be accepted.

REPORT OF THE REPRESENTATIVE TO THE NATIONAL RESEARCH COUNCIL

In the absence of Mr. W. A. Riley, Dr. Payne, Chairman of the Division of Biology and Agriculture of the National Research Council, was requested by President Flint to discuss some of the activities of the National Research Council as they affect the field of Entomology. Dr. Paine spoke as follows:

"It seems to me quite clear from the way in which the Division has functioned in the past, that it is a place where biologists can come and bring problems on which they need help, and I must say, I have not had as many of those problems brought to the Division this year as I think should have been brought.

I sent out a large number of letters of inquiry to representative biologists over the country and found a large number of these men were not very well informed concerning the Division itself and its various activities They had heard of it for the most part, but that was about all they knew.

I feel it is the function of the Division to keep the biologists of the country a little better informed than they seem to be at the present time.

A past history of the whole Council, will be published sometime during the spring. It will be rather brief. Dr. Cattell has given us a twenty-thousand-word article to be published in a series of short articles. There are one or two general articles on the Council as a whole, and then a series of articles on the seven Scientific Divisions. I shall write a brief history, about 2000 words, on the Division of Biology and Agriculture, and those articles will be published at some time during the spring. We hope these articles will be read by biologists.

I should like to see the biologists a bit better informed as to what the Division is, what its function is, what it can do for them."

The President also called upon Dr. Lutz for further discussion of the work of the Council and the proposed plans for reorganization. Dr. Lutz spoke as follows:

"I will say this, very briefly, just as Dr. Payne has told you, that the entomologists appear to me not to have made the use of the National Research Council that they could and should have. If we act on the theory that the National Research Council is good for something, I think the entomologists ought to look into the matter and see whether it is not good for something to the entomologists.

As Advisory Representative for a couple of years, and now as representative of a Group 8, I haven't anything to do. The entomologists have not given me any work. The other society has. As I wrote the President, the only report I had was that this society asked for nothing and got what it asked for.

As to the two plans of reorganization, I think that there is not much chance for difference of opinion. Plan number two, continuing the group representation as it now is, is by far the better plan, the more democratic plan."

The President expressed the appreciation of the Association to both Dr. Lutz and Payne for presenting the information to the entomologists present and stated that it was a subject to which more attention should be given than has hitherto been the case.

REPORT OF BOARD OF GOVERNORS OF THE CROP PROTECTION INSTITUTE

"I may say the largest of the corporations I have been in touch with are not obligating themselves at the present time for anything like the periods ahead that they ordinarily would, some of them for no period longer than three months."

Conditions have been difficult throughout 1932 in the matter of financial support of research by industrial funds. Large corporations everywhere have reduced their research activities severely. Nevertheless, the Institute has been directing this year sixteen active research projects. It is closing the year with as much productive work on hand as it has had in any other year in its history.

In part this has been due to following a policy of laying before corporations the desirability of carrying on preliminary exploration in this period of reduced business activity. It has seemed logical that an industrial enterprise should be searching for new outlets and new products at the present time, so that it may be in position to engage in more comprehensive development later and may have a groundwork laid for such plans. Preliminary exploration of this kind can be done at moderate expense and can be carried along step by step over relatively short periods of obligation.

The following is a brief summary of the year's projects:

NEW COPPER FUNGICIDES. Regular full-time project. The Nichols Copper Company and The Copper and Brass Research Association.

A search for new and better copper compounds adapted for control of plant diseases and intended to eliminate the plant injury often caused by present compounds. Carried out in cooperation with the Delaware experiment station. Work in progress and has resulted in the discovery of some new materials of definite promise.

COPPER SALTS IN RELATION TO PLANT NUTRITION AND PLANT STIMULATION. Regular, full-time project. The Nichols Copper Company and The Copper and Brass Research Association.

Carried on in cooperation with the Delaware Experiment Station. The work is yielding results that appear to shed a new light on the relation of copper to plant growth.

OIL SPRAYS FOR APPLICATION TO PLANTS. Regular full-time project. The Standard Oil Company of Indiana.

Conducted in cooperation with the Illinois Experiment Station. Two materials are on the market which have been developed in the course of this investigation and additional combinations and materials are in process of development. The work is still in progress.

PLANT INTRODUCTION AND IMPROVEMENT. Regular full-time project. The Standard Oil Company of New Jersey.

Carried on with the cooperation of the New Jersey Experiment Station. The work is yielding information of material promise.

FLOTATION SULPHUR. Regular full-time project. The Koppers Company.

Conducted with the cooperation of the Illinois Experiment Station, and the New Jersey Experiment Station. The colloidal or flotation sulphur developed in the course of this project is now in extensive use by fruit growers.

PYRETHRUM EXTRACT AND PYRETHRUM DUST. Regular full-time project. J. C. Makepeace.

Maintained in cooperation with the Massachusetts Experiment Station. Extensive data have been accumulated as to the best methods of extracting pyrethrum

flowers for the manufacture of sprays intended for application to plants and the best methods of impregnating inert dusts with the active principle of pyrethrum flowers.

THE USE OF INDUSTRIAL ADHESIVE TAPE FOR THE PROTECTION OF GRAFTS. Part time project. Johnson & Johnson.

Conducted in cooperation with the Wisconsin Experiment Station. The project has developed a practical method of using industrial adhesive tape in such way as to reduce losses from crown gall.

RELATION OF OIL SPRAYS TO CONTROL OF THE FRUIT MOTH. Regular full-time project. The California Spray-Chemical Corporation.

Conducted in cooperation with the Delaware Experiment Station and brought to a close in the present year.

OIL SPRAYS FOR THE CONTROL OF THE CODLING MOTH. Part-time project. The California Spray-Chemical Corporation.

Carried on with the cooperation of the Washington Experiment Station. Work is in progress.

NEW CONTACT INSECTICIDES. Preliminary study. The Dow Chemical Company.

Carried on in cooperation with the Iowa Experiment Station. New and promising materials have been developed and are in process of preparation for commercial use. The work is still in progress.

IODINE SALTS AS FUNGICIDES. Part-time project. The Iodine Educational Bureau, Inc.

Carried on in cooperation with the New Jersey Experiment Station and brought to a close at the end of the present calendar year.

NEW CONTACT INSECTICIDES. Regular full-time project. Sharples Solvents Corporation

A thorough search in the possibilities of certain groups of chemicals. This project conducted in cooperation with the Ohio Experiment Station. Promising results have been secured

THE USE OF CARBON DIOXIDE IN CONNECTION WITH FUMIGATION AND IN CONNECTION WITH THE APPLICATION OF SPRAY MATERIALS Full-time project. Liquid Carbonic Corporation.

A thoroughly organized project carried on in cooperation with the Iowa Experiment Station. Extensive data have been secured as to the practical utilization of carbon dioxide in connection with toxic gases that otherwise would be dangerous. Other phases of this study are in progress.

FUNGICIDES IN COMBINATION WITH OIL SPRAYS. Regular full-time project. California Spray-Chemical Corporation.

Carried on in cooperation with the New Jersey Experiment Station. New fungicides compatible with oil sprays have been developed, one or more of which offers definite promise.

NEW CONTACT INSECTICIDES COMBINED WITH NEW FUNGICIDES. The National Aniline & Chemical Co.

Search of extensive groups of organic compounds which have not hitherto been explored. Carried on in cooperation with the New Hampshire Experiment Station and the Delaware Experiment Station. Several new materials have been discovered of apparently marked significance. The work is still in progress.

DEVELOPMENT OF NEW INSECTICIDES FROM CERTAIN CHLORINATED COMPOUNDS. Preliminary Study. The Halowax Corporation.

Carried on in cooperation with the New Hampshire Experiment Station and the

Ohio State University. At least one new compound has been devised which is giving excellent and important results.

W. C. O'KANE,
Chairman, Board of Governors

Upon motion regularly made and seconded, it was voted the report be adopted.

REPORT OF TRUSTEE OF TROPICAL PLANT RESEARCH FOUNDATION TO AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

As your representative on the Tropical Plant Foundation I may report that there has been little to record of an encouraging character during the past year. Funds available for research have been much reduced, and, as anticipated last year, the Laboratory at Baragua, Cuba, which was supported by the Cuba Sugar Club, has been closed. Fortunately most of the staff were placed in time to avoid serious individual difficulties. Professor Van Dine has retired to his old home in Louisiana and up to date I have not learned of his engagement in other work. The Washington office of the Foundation has been temporarily closed and Doctor Crocker, the Director of the Boyce Thompson Institute and acting Director of the Foundation, is caring for the business of the Foundation, so that it is hoped that with change of conditions the activities of the Foundation may be resumed.

Projects outside of the sugar investigations are being taken care of on a limited scale. It is hoped that the Association will continue its interest in the Foundation and any suggestions from its members will be welcomed at any time.

Respectfully submitted,
HERBERT OSBORN, *Trustee*

Upon motion regularly made and seconded, it was voted that the report be accepted.

REPORT OF REPRESENTATIVE ON THE COUNCIL OF THE UNION OF BIOLOGICAL SOCIETIES

(Mr. Crosby was unable to be present at the meeting of the Union of Biological Societies or this meeting, and Mr. Melander was appointed to represent the Society at the meeting at Atlantic City.)

Annual Meeting at Hotel Traymore, December 27, 9:30 A. M., 17 present, A. F. Woods elected Chairman.

A motion to amend the constitution to provide that the President and Secretary of each society shall constitute the Council was tabled.

W. C. Curtis was elected President to succeed himself. E. B. Cowdry was elected Secretary. On motion the Chairman appointed Drs. Schram, Dosher and McGaff a committee to select three replacements on the Executive Committee.

Dr. Houser presented the report of the Treasurer of the Council showing a balance of $502.75.

That is not the funds of the Union, but the funds available for the Council of the Union.

A lengthy report on the condition and prospects of Biological Abstracts was presented by Editor Schram. The Rockefeller foundation will continue its support

during 1933, though the amount is not yet determined. Special support by the Foundation makes possible the appearance of the Index for Vol. 3 next June and the Index for Vol. 6 shortly after. Some 26,000 abstracts were published during 1932. Thirty-five journals are cooperating to assure uniformity in abstracting by attaching an informative blank on galley proof to authors. Since manuscript is accumulating faster than it can be printed, the Council is considering more economical means of printing Biological Abstracts. Dr. Schram considers that the integration of all biological sciences as provided by Biological Abstracts is a major and basic feature.

(Signed) A L. MELANDER

Upon motion regularly made and seconded it was voted that the report be accepted.

REPORT OF THE COMMITTEE ON NOMENCLATURE

"In the absence of the Chairman of the Committee, Mr. Hyslop, I have been asked to present the report of your Committee on Nomenclature, on common names. The committee has prepared a list of seventy-one common names and four changes in common names for your consideration.

As heretofore, I would move, Mr. Chairman, that this report be accepted without the reading of this list of seventy-five names, and that the committee take the usual action of distributing the list to the membership of the Association for their consideration and acceptance or rejection of these names, as they may see fit."

F. C BISHOPP

The motion was put to a vote and carried.

REPORT OF THE COMMITTEE ON ENDOWMENT

(No report was presented)

REPORT OF THE BOARD OF TRUSTEES FOR THE PERMANENT FUND

During the past year funds have been withdrawn from the savings accounts and five United States Fourth Liberty Loan Bonds have been purchased. By authority of the Executive Committee there was transferred to this fund $750 from the Association Fund and $250 from the Journal Fund. These amounts, together with accrued interest, have been added during the year. The fund has been audited and the report of Ernest L. Millington, State Accountant, will be found with the other financial transactions of the Association.

Respectfully submitted,

A. I. BOURNE, *Chairman*
W. P. FLINT
H. B. HUNGERFORD
C. L. MARLATT
C. W. COLLINS

Upon motion regularly made and seconded, it was voted that the report be accepted.

REPORT OF COMMITTEE ON INSECT COLLECTIONS

This committee has been operating under the title of Committee on National Museums. It was originally appointed to encourage much needed federal support of the Division of Insects of the U. S. National Museum. The purposes for which the committee was appointed were accomplished, at least in part, a committee of the Entomological Society of America cooperating. During recent years the committee has been inactive. Recognizing the desirability of having a record of the private collections,[1] your committee sent a questionnaire to perhaps 300 persons who might possess a private collection. Replies were received from 137 persons, 90 of whom possess private collections and are reported in the following table. These collections represent about 2,000,000 specimens, with over 10,000 types and 16,000 other kinds of types.

This report is submitted with the recommendation that it be published and that the name of the committee be changed to that of the Committee on Insect Collections.

Persons possessing collections not listed here are requested to submit data to the committee to permit it to complete the list of private collections in its report next year.

The following reported that they do not now possess a private collection but will assist in making determinations as follows:

Foster H. Benjamin, North America Macro Lepidoptera.

F. C. Bishopp, Ticks, Anoplura, Mallophaga, Diptera and Fleas, related to Medical Entomology.

J. Chester Bradley, Scoliidae.

P. P. Calvert, Odonata. Determinations by arrangement.

E. P. Felt. Determinations by arrangement.

C. P. Gillette. Determinations by arrangement.

H. B. Hungerford, Homoptera. Special group.

P. B. Lawson, Insects in specialty.

A. W. Lindsey, Hesperidae of U. S.

J. B. Parker. Determinations by arrangement.

The following report disposal of their private collections:

J. M. Aldrich—U. S. National Museum.

Jos. C. Chamberlin—Collection of Chelonethids donated to Stanford University in 1929.

J. A. Comstock—Collection donated to Los Angeles Museum several years ago.

Norman Criddle—Collection incorporated with Canadian laboratory collection at Treesbank.

P. P. Calvert—Odonata deposited in Philadelphia Academy of Nat. Sci. in 1922.

M. J. Elrod—Collection deposited in Montana State University Collection.

U. S. Grant IV—Collection donated to San Diego Soc. Nat. Hist.

H. B. Hungerford—Collection in Snow Collection of Insects at University of Kansas.

J. A. Hyslop—Collection donated to U. S. National Museum.

A. C. Kinsey—Collection incorporated with Indiana University Insect Collections.

[1]The corresponding committee of the Entomological Society of America has made a rather complete record of the Institutional collections.

SUMMARIZED DATA ON PRIVATE COLLECTIONS

Name and address	Groups represented	Geographical distribution of collection	No. specimens in collection	No. species in collection	No. types in collection	No. of types, other than true types	Is collection[1] available to other workers	Plans for disposition of collection	Will you[2] determine species in your specialty for others
Charles P. Alexander Mass. State College Amherst, Mass.	Tipulidae (Diptera)	World	50,000	5,160	2,394	1,515	Yes	A major American Museum	Yes
H. W. Allen U. S. Ent. Labry., Moorestown, N. J.	Tachinidae (Diptera)	N. America	3,000	200	None	Several	Yes	No plans	Now working on Tipulidae
A. W. Andrews, 133 Tyler Ave., Detroit, Mich.	Coleoptera. Also Hymenoptera, Diptera and Hemiptera	Boreal America Michigan	50,000		None	Several	Yes	No plans	Sometimes
John W. Angell, 316 W. 88th St., New York, N. Y.	Lucanidae Cicindelidae (Coleoptera)	World No. America	5,500		10	25	Yes	U. S. N. M.	Yes
W. V. Balduf, Univ. Illinois Urbana, Ill.	Chalcidoidea (Hymenoptera)	United States			None	14	Yes	No plans	Yes in Tribe Decatomini.
E. D. Ball, Univ. Arizona, Tucson, Ariz.	Homoptera, except Aphididae, Aleyrodidae and Coccidae.	No. and S. America	35,000	2,350	510	600	Yes	No plans	Yes
Charles A. Ballou, Jr., 77 Beekman St., New York, N. Y.	Histeridae (Coleoptera)	World	25,000	1,500	None	50	Yes	No plans	Yes

[1]Many of these collections are in private homes and the owner should be consulted as to time when collection can be studied.
[2]It is always advisable for one to consult the specialist before submitting specimens for determination.

SUMMARIZED DATA ON PRIVATE COLLECTIONS—*Continued*

Name and address	Groups represented	Geographical distribution of collection	No. specimens in collection	No. species in collection	No. types in collection	Types, other than true types	Is collection available to other workers	Plans for disposition of collection	Will you determine species in your specialty for others
H. G. Barber 2222 Q St., N. W. Washington, D. C.	Hemiptera Lygaeidae	U. S. and Neotropical World	40,000	3,500	50	575	Not at present	No plans	Yes
Ernest L. Bell, Flushing, N. Y.	Hesperidae (Lepidoptera)	World	18,500	1,600	40	Many	Yes	Amer. Mus. Nat. Hist.	Yes
Bernard Benesh, 1961 Fremont St., Chicago, Ill.	Lucanidae (Coleoptera)	World	2,300	286	None	2	Yes	No plans	Yes
Cornelius Betten Cornell Univ., Ithaca, N. Y.,	Trichoptera	No. America	8,000	250	18	175	Yes	No plans	Yes
Henry Bird, 600 Milton Rd., Rye, N. Y.	Miscellaneous for Biological studies	U. S.	Few thousands	Few hundred	30	100	Yes	Amer. Mus. Nat. Hist.	Yes
Frank E. Blaisdell, Sr., Calif. Acad. Sci., San Francisco, Cal.	Coleoptera	U. S.	100,000	Several thousand	300	Several hundred	Yes	Calif. Acad. Science	Yes in Tenebrionidae and Melyridae
F. S. Blanton P. O. Box 786 Babylon, L.I., N. Y.	Diptera, especially Trypetidae	N. America	15,000		None			No plans	Yes in Trypetidae
Harold R. Brisley Box 173, Clemenceau, Ariz.	Chrysomelidae (Coleoptera)	Western U. S.	3,000	200	None	None	Yes	No plans	Yes
S. W. Bromley, Ohio State Univ Columbus, O.	Asilidae (Diptera) Misc. Orders	World U. S.	30,000	7,000	25	100	Not at present	No plans	Yes

J. R. de la Torre Bueno, 38 DeKalb Ave., White Plains, N. Y.	Heteroptera	World	40,000	4,000	50	100	Yes	No plans	Yes
C. Francis Byers, Univ. Florida, Gainesville, Fla.	Odonata	Florida and Michigan	2,000	150	None	2	Yes	? Univ. Mich.	Yes
Samuel E. Cassino, Salem, Mass.	Geometridae (Lepidoptera)	America N. of of Mexico	25,000		All Swett & Cassino types	Many	Yes	No plans	
William C. Cook, Box 488, Davis, Calif.	Noctuidae (Lepidoptera)	Western U. S.	2,500	300	None	2	Yes	No plans	Yes
R. A. Cooley, Hamilton, Mont.	Ixodidae (Arachnida)	N. Amer. and Africa	5,000	60	None	2	Yes	No plans	Yes in genus Dermacentor
C. M. Dammers, R. 3, Riverside, Calif.	Lepidoptera Coleoptera	So. Calif.	3,192	605	1	None	Yes	Los Angeles Museum	No
P. J. Darlington, Jr., Mus. Comp. Zool., Cambridge, Mass.	Coleoptera, esp. Carabidae, Dytiscidae and Parnidae	America N. of Mexico	32,500		8	49	Yes	No plans	Yes
Wm. T. Davis, 146 Stuyvesant Pl., Staten Is., N. Y.	General	Eastern U. S.			Some		Yes	Staten Island Inst of Arts and Science	Yes in Cicadidae
Frank D. DeGant, 4204 Bush Ave., Cleveland, O.	Ichneumonoidea (Hymenoptera)	Ohio	3,000				Yes	Ohio Biological survey	Yes
Carl J. Drake, Ames, Iowa	Hemiptera	World	Several 1000	*	300	400	Yes	No plans	Yes
Carl D. Duncan, Box 4, Stanford Univ., Cal.	Vespidae (Hymenoptera)	Pacific Coast	8,000	2,500	None	None	Not at present	Calif. Acad. Science	Yes in Vespidae and Bembecidae

*Collection contains 95 per cent of described species of Tingidae.

SUMMARIZED DATA ON PRIVATE COLLECTIONS—*Continued*

Name and address	Groups represented	Geographical distribution of collection	No. specimens in collection	No. species in collection	No types in collection	Types, other than true types	Is collection available to other workers	Plans for disposition of collection	Will you determine species in your specialty for others
Norman S. Easton, Fall River, Mass	Coleoptera	Fall River		1,600				Boston Soc Nat Hist	
Theo. H. Eaton, Jr., International House, Berkeley, Calif	Hesperidae (Lepidoptera)	World	4,000	1 200	None	None	Not at present	No plans	Not at present
Addison J. Ellsworth, R 2, Johnson City, N.Y.	Lepidoptera	Local					Yes	Cornell Univ [4]	No
Alfred Emerson, Dept. Zoology, Univ. Chicago, Chicago, Ill.	Isoptera	World	6 000	1,046	923 types or compared with types		Yes	Amer Mus Nat Hist	Yes
E. O. Essig, Univ. Calif., Berkeley, Calif	Aphididae and Coccidae (Homoptera)	World	50,000	2,000	None	100	Yes	Calif Acad Science	Not at present
J H. Evans, Oskhosh H, Oskhosh, Wis.	Hemiptera, esp Phymatidae	N and S America	500	26 (Phymatidae)	None	60	Yes	U S N M. or Ill N. H Surv	Yes
Geo. P. Englehardt, 28 Club Way Hartsdale, N. Y	Aegeriidae (Lepidoptera)	N America	3 000	150[5]	24	17	Yes	U S N M.	Yes
John M. Enburg, 5141 Baltimore Ave, Philadelphia, Pa	Lepidoptera	World	750				Yes	Phila Acad Nat Sci	
H. C. Fall Tyngsboro. Mass	Coleoptera and Lepidoptera	America N of Mexico	118 000	20 000	1 271	125	Yes	No plans	Yes

H. T. Fernald, 707 E. Concord Ave., Orlando, Fla.	Sphecinae (Hymenoptera)	N. America	Several thousand		2	50	Yes	[4]U. S. N. M.	Yes
Geo. H. Fields, 1859 Julien Ave., San Diego, Calif.	Coleoptera and Lepidoptera	Lower California	12,500	2,175	None	None	Yes	San Diego Nat. Hist Mus.	Not at present
Philip Fischer, 514 Dodge St., Buffalo, N. Y.	All orders	World			None	None	Yes		No
Wm. T. M. Forbes, Cornell Univ., Ithaca, N. Y.	Lepidoptera	New England States	3,500	1,000	None	None	Yes	No plans	Yes
Robt. Fouts, 357 N. Harper Ave., Hollywood, Calif.	Hymenoptera	Nearctic	35,000		100	200	Yes	No plans	Yes in Serphoidea (Proctotrypoidea)
S. B. Fracker, Bur. Pl. Quarantine, Washington, D. C.	Heteroptera, especially Coreidae and Reduviidae	N. and S. America	2,500	800	8	6	Yes	No plans	Yes
C. A. Frost, 67 Henry St., Framingham, Mass.	Coleoptera	U. S. and Canada	40,500	7,200	16	231	Yes	Mus. Comp. Zoology	Yes
S. W. Frost, Arendtsville, Pa.	Leaf Miners (Coleoptera, Diptera and Lepidoptera)	N. America	2,825	500	None	151			
B. B. Fulton, N. Car. St. Col., Raleigh, N. C.	Orthoptera Dermaptera	U. S	6,228	514	None	54	Yes	No plans	During winter
John S. Garth, 326 Molino Ave., Long Beach, Calif.	Rhopalocera (Lepidoptera)	West coast	7,000	550	None	5	Yes	No plans	Yes
W. J. Gerhard, 8037 Kimbark Ave., Chicago, Ill.	Hemiptera and Homoptera	N. America	8,476	1,440	None	56	Yes	Field Mus. Nat. Hist.	No

[4]During illness collection was given to Cornell University. Although fourscore years old, this collector is making a new collection.
[5]Collection represents 95 per cent of known species

SUMMARIZED DATA ON PRIVATE COLLECTIONS—*Continued*

Name and address	Groups represented	Geographical distribution of collection	No. specimens in collection	No. species in collection	No. types in collection	Types, other than true types	Is collection available to other workers	Plans for disposition of collection	Will you determine species in your specialty for others
Bertram I. Gerry, 136 State House Boston, Mass.	Chironomidae Culicidae (Diptera)	New England	7,000						Yes
Henry G. Good, Ala. Poly. Inst., Auburn, Ala.	Cerambycidae, Elateridae, Carabidae, Buprestidae (Coleoptera)	U. S.	1,998	625	None	1	Yes	No plans	Not at presen
J. D. Gunder, 310 Lindor Vista Ave., Pasadena, Calif.	Lepidoptera	U. S. and Canada	10,000		200	Many	Yes	To a well-known institute	Yes
Halbert M. Harris, Iowa State College, Ames, Iowa	Hemiptera	America	20,000	1,300	49	Many	Yes	No plans	Yes, especially Nabidae, Anthocoridae, Gerridae and Corizidae
Albert Hartzell, Yonkers, N. Y.	Cicadellidae (Homoptera)	N. America	2,500	200	None	3	Yes	Ohio State Univ.	Yes
Melville H. Hatch, Univ. Washington, Seattle, Wash.	Coleoptera	World	100,000	10,000	Most of Hatch's species	20		No plans	Yes in Silphidae and Leptodiridae
Graham Heid, 1239 Bay St., Alameda, Calif.	Rhopalocera, (Lepidoptera)	N. Am., Africa, Indo-Australia	8,000	2,000	None	11	No	Calif. Acad. Science	Yes in Lycaenidae
W. J. Holland,[6] Carnegie Museum, Pittsburgh, Pa.	Lepidoptera	World	250,000	25,000	2,000	2,000	Yes	Probably Carnegie M.	Yes
C. H. Kennedy Ohio State Univ., Columbus, O.	Hymenoptera	Ohio	30,000						

H. H. Knight, Iowa State College, Ames, Iowa	Miridae (Hemiptera) Coleoptera	N. America	75,000	1,975	673	208	Yes	No plans	Yes in Miridae
Geo. F. Knowlton, Utah State Agr. Col., Logan, Utah	Aphididae (Homoptera)	U. S. and Japan	7,500 slides	450	5	200	By arrangement	U. S. N. M. and Utah Exp. Sta.	Yes
W. H. Larrimer, Bur. Entomology, Washington, D. C.	Cicadellidae (Homoptera)			175		2		U. S. N. M.	
Charles W. Leng, Staten Is., N. Y.	Coleoptera	U. S	100 000	10,000	Few	Many	Yes	No plans	Not at present
W. W. Long, Eighty Four, Pa.	Lepidoptera	U. S.	3,600	900	None	None	Yes	No plans -	No
Edith W. Mank, 12 Reservoir St., Lawrence, Mass.	Coleoptera	N. America Europe	13,600	7,000				Mt. Holyoke College	
W. M. Mann, Nat'l Zool. Park, Washington, D. C.	Formicidae (Hymenoptera)	World	100,000	3,500	50	600	Yes	U. S. N. M.	Yes
W. L. McAtee, Bur. Biol. Surv., Washington, D. C.	Rhynchota	District of Col.	17,677	1,585	109	959	Yes	U. S. N. M.	Not at present
E. A. McGregor, Lindsay, Calif.	Tetranychidae (Arachnida)	U. S.		Most Amer. species	None	All McGregor sp.	Not at present	U. S. N. M.	Yes
Don C. Meadows, Avalon, Santa Catalina Is., Calif.	Lepidoptera	N. America, esp. Channel Is. of Cal.	10,000	1,000	None	2	Yes	Plans made	
E. P. Meiners, 6000 Delmar Blvd., St. Louis, Mo.	Lepidoptera	N. America	20,000		None	None	Yes	No plans	No

[6]In letter dated Nov. 5, 1932, shortly before his death, Doctor Holland states that his personal collection included many types or paratypes of species described by W. H. Edwards, Theodore L. Mead, Wm. Doherty, Otto Staudinger, Geo. D. Hulst, Lord Washingham, E. L. Ragonot, S. H. Scudder, Henry Edwards, J. D. Gunder, William Schaus, A. G. Butler, G. F. Hampton, J. B. Smith, and W. J. Holland. In the Carnegie Museum collection of all orders of insects and in the Holland collection of Lepidoptera, housed together in the Museum, there are perhaps not less than 6,000 types or paratypes.

SUMMARIZED DATA ON PRIVATE COLLECTIONS

Name and address	Groups represented	Geographical distribution of collection	No. specimens in collection	No. species in collection	No types in collection	No. of types, other than true types	Is collection available to other workers	Plans for disposition of collection	Will you determine species in your specialty for others
C. E. Mickel, Univ. Minn. Minneapolis, Minn.	Mutillidae (Hymenoptera)	U. S	1,000	100	1	75	Yes	No plans	Yes
Harlow B. Mills, Iowa State College, Ames, Iowa	Collembola Protura	Cent. and West N America		175	None	30	Yes	No plams	Yes
Mrs. Eliz. M. Moffatt, 273 S. Witmer St., Los Angeles, Calif.	Arachnida	Great Lakes Reg.	1,600					Field Mus. Nat. Hist.	Not at present
B. E. Montgomery. Purdue Univ., Lafayette, Ind.	Odonata Coleoptera	World Indiana	5,000 4,500	450 1,000	None	Few	Yes	No plans	Yes in Odonata
Dudley, Moulton, St. Dept. Agr., Sacramento	Thysanoptera	World	25,000	800	1,000	5,000	Yes	No plans	Yes
James G. Needham, Cornell Univ. Ithaca, N. Y.	Odonata	World					No	Cornell Univ.	Yes
H. I. O'Byrne, Hatton Lane, Brentwood, Mo.	Lepidoptera	N. America	2,475	597	None	None	Yes	No plans ·	Yes
Chris E. Olsen, Amer. Mus. Nat. Hist., New York, N. Y.	Hemiptera Homoptera	N. America	10,000	1,000	5	45	Yes	No plans	No
Herbert Osborn, Ohio St. Univ., Columbus, O.	Homoptera	N. and S. America	50,000	4,500			Yes	Ohio State Univ.	Limited
R. H. Painter, Kan. St. Agr. Col., Manhattan, Kan.	Diptera	Nearctic and Neotropical	15,433	800	22	472	Yes	No plans	Yes in Bombyliidae and Apioceridae

H. J. Reinhard, College Station, Tex.	Tachinidae and Sarcophagidae (Diptera)	N. and S. America and Europe		450	None	400	Yes	No plans	Yes
E. A. Richmond Brockton, Mass.	Hydrophilidae (Coleoptera)	Nearctic and Palearctic	250	50	None		No	Mus. Comp. Zool.	Yes
Carl Selinger, 4406 Greenview Ave., Chicago, Ill.	Coleoptera	N. America	12,414	4,015	None	None	Yes	No plans	No
M. R. Smith, A. & M College, Miss.	Formicidae (Hymenoptera)	N. America	6,000	400	25	Many	Yes	U. S. N. M.	Yes
R. C. Smith, Kan. St. Agr. Col., Manhattan, Kan.	Neuroptera esp. Chrysopidae	N. America and West Indies	1,400	140	None	60	Special arrangements	No plans	Yes
K. D. Sloop[7], P. O. Box 297, Alhambra, Calif.	Coleoptera	So. Calif.	20,500	2,766		6	Yes	No plans	So. Calif. onl
H. T. Spieth, Col. City N. Y., New York, N. Y.	Ephemerida	East of Mississippi	25,000		None	None	Yes	No plans	Yes
A. N. Tissot, Fla. Agr. Exp. Sta., Gainesville, Fla.	Aphididae Cicadellidae (Homoptera)	U. S., esp. Florida	2,600	235	None	200 Slides	Yes	No plans	Yes in Aphididae
Ralph Voris, St. Teachers Col., Springfield, Mass.	Staphylinidae (Coleoptera)	U. S.	50,000				Sp. arrangements	No plans	Yes
Fred W. Walker, Monticello, Fla.	Orthoptera[8] Dermaptera	World	4,000	350	None	1	Yes	No plans	No
L. H. Weld, E. Falls Church, Va.	Cynipidae Hymenoptera	N. America	14,000	400	None	1,089	Yes	No plans	Yes
H. F. Wickham, Iowa City, Ia.	Coleoptera	N. and Cent. America			Many	Many	Not at present	No plans	Arrange
A. B. Wolcott, Field Mus. Nat. Hist., Chicago, Ill.	Cleridae (Coleoptera)	World	2,160	635	68	39	Yes	No plans	Yes

[7]Collection at 2924 Nina St., Pasadena, Calif., until Aug 1, 1933.
[8]Original collection of 40,000 Orthoptera now in University of Michigan Museum.

P. B. Lawson—Collection in Snow Collection of Insects at University of Kansas.
A. W. Linsey—Collection of Hesperidoidae sold to Carnegie Museum in 1929.
A. P. Morse—Collection in Peabody Museum of Salem, Mass.
J. B. Parker—Collection in U. S. National Museum.
James A. G. Rehn—Collection in Philadelphia Academy of Nat. Sci.
Fred W. Walker—Collection of Orthoptera in Univ. Michigan Museum.
E. B. Williamson—Collection of Odonata donated to University of Michigan Museum.
M. Wirtner—Collection of Homoptera & Hemiptera given to St. Vincent College at Latrobe, Pa.
W. S. Wright—Collection given to San Diego Soc. Nat Hist.

Respectfully submitted,
J. J. Davis, *Chairman* R. W. Harned
C. P. Alexander H. H. Knight
E. C. Van Dyke

The motion to adopt the report was put to a vote and carried

REPORT OF THE COORDINATING COMMITTEE ON PROGRAM

Mr. Alvah Peterson stated that no special report was necessary. The committee simply passed upon the programs as prepared by the secretaries. He called attention to the fact that this had constituted the function of the committee for several years and doubted whether under present conditions continuance of this committee was necessary.

After some discussion it was voted to accept the report and that the committee be discharged.

REPORT OF COMMITTEE TO FORMULATE PLANS FOR INVESTIGATIONS OF THE CODLING MOTH FROM BIOLOGIC AND CONTROL STANDPOINTS

This committee has continued to function as in previous years On invitation extended by J. S. Houser of the Ohio Experiment Station, a conference on the codling moth was held at Wooster, Ohio, on March 2, in conjunction with the annual meeting of the North Central States Entomologists. The work of the previous season was reviewed in considerable detail, and there was some discussion of the research programs for the coming season. On vote of the conference, the committee compiled a statement covering the research programs in contemplation by most of the State and Federal organizations, which are giving attention to the codling moth problem. This statement, together with the minutes of the meeting, has been circulated among the entomologists participating. By common consent, the committee sponsored, at the same time, a similar conference on the oriental fruit moth, a problem in which much the same group of entomologists is interested.

Respectfully submitted,
B. A. Porter G. A. Dean
P. J. Parrott Leroy Childs
W. A. Ross J. S. Houser

Upon motion regularly made and seconded, it was voted that the report be adopted.

REPORT OF THE COMMITTEE ON RESEARCH WORK ON THE CONTROL OF THE EUROPEAN CORN BORER, REPORT OF THE JOINT COMMITTEE

Mr. Dean was not present, and the report was presented by Mr. J. J. Davis.

Owing to weather conditions which were adverse to the flight of the European corn borer moths very little additional spread of the insect occurred in 1932. New infestations were found in nine townships in Indiana, six townships in Maryland, one township in Kentucky, three townships in Pennsylvania, and two townships in Virginia. The present known infested area includes the states of Wisconsin, Michigan, Indiana, Kentucky, Ohio, West Virginia, Pennsylvania, New York, New Jersey, Maryland, Virginia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, and all of the corn growing area in Canada except the western provinces. The two-generation strain of borer is known to be present in Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, Virginia, Maryland, and parts of New Jersey and New York, and in Canada, Nova Scotia, and New Brunswick. So far as known the one-generation strain of borer occurs in the remainder of the infested area.

The increase in borer population in 1932 again emphasizes that the European corn borer is one of the most potentially destructive crop pests ever introduced into America. This fact calls for the continued cooperation of the farmer, the scientist, the educator, and all State and Federal administrative officials.

The joint committee of entomologists, agronomists, agricultural engineers, agricultural economists, and animal husbandmen, commends the efforts of all farmers practicing recommended control measures and of those engaged in the research, regulatory, and educational activities.

In considering the progress and value of corn borer investigations it should be noted that many of the results of these investigations have an immediate application in the betterment of agricultural practices, regardless of the corn borer.

The committee recognizes the necessity for the continuation of the research, educational and regulatory programs of the State and Federal governments and earnestly recommends the appropriation of the funds needed to maintain them as suggested later in this report. The committee recommends this support only after due consideration of the absolute necessity of holding current governmental expenditures to a minimum.

1. We reiterate our belief in the value of the federal quarantine regulations which nave undoubtedly been instrumental in preventing long distance spread of the insect and regret that funds were not made available for their continuance in the United States. To provide the information necessary as a basis for present and future state regulations and to aid in parasite introductions and other general control operations, it is urged that thorough scouting and infestation survey activities be continued and that funds be made available for this work. We recommend that the Canadian government continue its federal and provincial quarantine regulations which have proven of great value in the past.

2. That the educational agencies of the Federal governments of the United States and Canada and of the State and Provincial agricultural colleges, continue their

programs relating to the corn borer, particularly where control programs are being conducted, extending these to conform with the spread and abundance of the insect and with the increased knowledge gained through research.

3. The entomological investigations now in progress should be continued. The following studies on which material progress already has been made, should be especially stressed: The recolonization of those species of parasites already established in the United States which occur in numbers sufficient for this purpose and the collection and introduction of all other species of possible benefit in reducing infestation; the development of effective insecticides and their efficient application; and the evaluation of the effect of environmental factors on the corn borer.

4. While the development of immune varieties seems unlikely at this time, experiments point clearly to the probable development of high yielding resistant and tolerant varieties of corn which should be an important factor in control. To promote the development of such varieties, the corn breeding programs of the State and Federal governments should be continued and steps taken to correlate more effectively the work of the various agencies.

5. Inasmuch as control of the borer, as yet, depends largely upon mechanical means in the hands of growers, it is recommended that research and development work along mechanical lines by the agricultural engineers be continued and be strongly supported by the Federal Government and by the States, with a sincere effort being made to coordinate such activities through the Bureau of Agricultural Engineering. In such work it is recommended that attention should be directed first toward machine types now common on farms, in view of the fact that agriculture cannot easily avail itself of new types of equipment primarily for control until it has used to the best possible advantage the equipment now on farms.

The manufacturers are to be commended for their interest and loyal support in corn-borer work to date, and, in spite of the readjustment period, it is hoped that they will continue rapidly to convert development accomplishments into the commercial channels, so that the growers—who must carry the burden of control—will not be handicapped by the latest, practical, mechanical devices not being available to the public.

6. Since the corn borer control practices developed and proposed may change the organization and income of the farm, it is important that the relation of these practices to the entire farm business be determined and recommendations made for specific conditions. Proposals including changes in cropping systems, complete utilization of corn, substitute crops, changes in corn acreages, and labor and equipment costs should be worked out in line with the objective of maximum returns from farming.

7. In view of the continued increase in the intensity and spread of European corn borer infestation during the past year, the committee recommends a continuance of studies to determine the influence of different borer populations on the feeding value of corn and the corn plant in different forms, the yield of feed nutrients per acre, and the influence of the corn borer and approved control measures upon the cost of production and quality of livestock products.

Respectfully submitted,

COMMITTEES

American Association of Economic Entomologists

G. A. DEAN — D. J. CAFFREY
L. CAESAR — T. J. HEADLEE
J. J. DAVIS

American Society of Agronomy

L. E. CALL — J. F. COX
W. L. BURLISON — R. M. SALTER
F. D. RICHEY

American Society of Agricultural Engineers

R. D. BARDEN — R. M. MERRILL
C. O. REED — A. L. YOUNG
W. C. HARRINGTON — R. H. WILEMAN

American Farm Economic Association

E. D. Hill	J. Coke
C. R. Arnold	Lynn Robertson
C. L. Holmes	R. R. Hudelson

American Society of Animal Production

E. W. Sheets	Paul Gerlaugh
F. G. King	G. A. Brown

T. B. Morrison

Upon motion regularly made and seconded, it was voted that the report be adopted

REPORT OF THE COMMITTEE ON RECOMMENDATION TO THE SECRETARY OF AGRICULTURE WITH REFERENCE TO NEEDS FOR FOREIGN STATIONS TO STUDY INSECT PESTS, PLANT AND ANIMAL DISEASES INTRODUCED OR LIKELY TO BE INTRODUCED

Your committee at this time can only report as it did one year ago, that there has been no progress and that under present economic and international conditions there seems little opportunity to advance in this matter. We believe that the support of such stations for the observation and study of potential insect immigrants and also possible useful species for biological control purposes will be of advantage, but there seems little probability that federal support for any increase in this direction can be secured in the near future. We suggest that the committee be discharged with the hope that it may be reorganized at such time as may seem opportune, or if the Society elect, the committee may be continued for the purpose of such contacts as may have promise, but with the understanding that positive advances are not expected in the near future.

Glenn W. Herrick
E. O. Essig
Herbert Osborn, *Chairman*

Acting upon the recommendation of Mr. Herbert Osborn, the Association voted to accept the report of the committee and that this committee be discharged until such a time as its reestablishment should be advisable.

REPORT OF THE COMMITTEE ON TRAINING OF ENTOMOLOGISTS

No report was presented.

REPORT OF THE SUB-COMMITTEE ON ENTOMOLOGICAL EXHIBITS FOR THE CHICAGO CENTURY OF PROGRESS EXPOSITION

The Century of Progress Exposition is progressing in spite of the present financial conditions in a very satisfactory way. The buildings are going up practically as planned in the first place. The exhibits are being placed. Many of them are already partly in place and the whole plan is being carried out as originally intended, that is,

the exhibit will be built around the central theme of showing the contributions of science to civilization during the last 100 years.

Through no lack of good faith on the part of the officials of the exposition, it has been absolutely necessary to cut down on some of the scientific exhibits which the exposition intended to finance. They have not been able to secure the funds for financing most of the entomological units as we planned them. These units are being reorganized and some of them will be financed by different commercial organizations, not as a piece of advertising, but merely with the statement on the exhibit that they are financed by such and such an organization.

Several of the exhibits, particularly the one in charge of Mr. Phillips, are going through just about as they had been planned, and I think the Assistant Chairman of Biological Exhibits, Mr. Pierson, is doing everything he can to get as many entomological exhibits in the Hall of Science and other places on the exhibit grounds as possible.

W. P. Flint, *President*

The motion that the report be adopted was proposed, seconded, put to a vote, and carried.

REPORT OF THE SPECIAL COMMITTEE ON POLICY OF THE JOURNAL OF ECONOMIC ENTOMOLOGY

Mr. W. B. Herms, Chairman of this Special Committee, was unable to be present. The report was presented by Mr. A. F. Burgess.

This committee, consisting of W. B. Herms, Chairman, W. E. Hinds, C. L. Metcalf and the undersigned, were appointed by President Flint at the close of the last annual meeting.

The work has been done by correspondence and it was anticipated that a meeting of the committee could be held before a report was submitted.

Unfortunately only two members of the committee are in attendance at this meeting and as the subject is of great importance to the Association and its membership and under present conditions there is a prospect of diminishing receipts for the Journal, it appears advisable that the subject be given further consideration before definite action is taken and that the president elect appoint a committee to continue this work.

Respectfully submitted,
A. F. Burgess
D. M. DeLong

The motion to adopt the report was proposed, seconded, put to vote, and carried.

President Flint: The next report is the Report of Delegates Representing the Association at the International Congress of Entomologists in Paris. This report was to be given by Mr. Hinds who, at the last minute, found he was unable to be present, but who sent the report which will be read by the Secretary.

REPORT CONCERNING THE FIFTH INTERNATIONAL CONGRESS OF ENTOMOLOGY HELD AT PARIS, FRANCE, JULY 18-24, 1932

The senior delegate to the Congress, representing the American Association of Economic Entomologists, was Dr. L. O. Howard, who was at that time living in France. As we have had no opportunity to confer regarding the report, the junior delegate is presenting a brief report as follows:

The special reason for selecting Paris as the meeting place for the Fifth International Congress of Entomology was to coordinate this meeting with the Centennial Celebration of the Entomological Society of France, the oldest national entomological organization in the world, we believe. The Centennial celebration occurred on July 16 and was a very beautiful and impressive affair held in the grand amphitheatre of the National Museum of Natural History and honored especially with the presence of M. Albert Lebrun, President of the Republic. Following the addresses of Dr. R. Jeannel, President of the Entomological Society of France and M. E. L. Bouvier, Honorary President of the Entomological Society of France, the official representatives of other nations and Entomological Societies were presented. Most of these delegates appeared in academic costumes or the official regalia of the societies which they represented. Many of them presented very elaborate engrossed greetings to the French Society. The whole occasion was characterized by very much beauty, dignity and grace.

On the following day many of the delegates took advantage of the opportunity to visit the grave of the pioneer French entomologist Latreille.

For the Congress sessions, representatives were present to the number of more than 400, from some twenty-three nations and five continents. The Congress was opened by Dr. Paul Marchal, President, and with Dr. R. Jeannel as General Secretary. The sessions included daily general sessions at which very many interesting addresses were presented by noted entomologists. There were also sections for general entomology, morphology, physiology, development, ecology, bio-geography, nomenclature, applied entomology, forest entomology, medical and veterinary entomology, and apiculture. Most of the addresses were given in French or German and little attempt was made to present abstracts of these talks in the English language. Only a small portion of the addresses were given in English and many of these were abstracted in French.

During the week the French Committee had arranged for a number of very interesting excursions and entertainments. Several elaborate banquets were held complimentary to all delegates. The Congress was received by the Mayor and officials of the city of Paris. Very interesting excursions were made to the forest and palace of Fontainebleau and to the exceedingly beautiful and elaborate royal estate at Versailles. Nothing was left undone by the French Committee that could add to the pleasure of their visitors.

The Sixth International Congress will be held at Madrid, Spain, in the summer of 1935 under the presidency of Professor Bolivar, who is probably the most noted of the living Spanish entomologists. An invitation was received to hold the Seventh Congress at Berlin, Germany, and the following meeting at Cairo, Egypt in 1941.

The party of American entomologists with their wives and friends accompanying numbered about forty-five, and most of these were housed at one hotel in Paris. Following the meetings, many of the American visitors participated in the special excursion to the Pyrennes section in South France and under the leadership of Dr. J. C. Bradley and Professor P. W. Claassen, many of them enjoyed a further tour

through a number of European countries. All American delegates are certainly under deep obligation to these two leaders for their part in making the entire tour so exceedingly comfortable and enjoyable in every respect.

Respectfully submitted,
W. E. HINDS,
Junior Delegate, Representing American Association of Economic Entomology

The official report of the Junior delegate was supplemented by brief remarks by Messrs. Herbert Osborn and J. J. Davis on their personal observations and experiences in connection with the Congress itself and the trips to points of historic and scientific interest in and about Paris and later excursions to other points in Europe. It was the unanimous opinion of all who were privileged to attend the Congress, that great credit was due Drs. Bradley and Claassen, whose efforts in behalf of the American Delegation to the International Congress of Entomologists at Paris resulted in such a full measure of success.

Upon motion regularly made and seconded, it was voted that the report be adopted.

President Flint appointed the following committees:

Nominating Committee: R. W. Harned, Chairman, P. J. Parrot and C. H. Richardson.

Committee on Resolutions: H. E. Hodgkiss, Chairman, B. A. Porter and C. R. Cutright.

FINAL BUSINESS SESSION

REPORT OF THE COMMITTEE ON RESOLUTIONS

Be it RESOLVED, That this Association express through its Secretary an appreciation to—

1—The management of the Chalfonte-Haddon Hall Hotel for providing the rooms in which these meetings have been held; and for the many other courtesies which have been extended to the Society during these meetings.

2—To Mr. P. W. Claassen and Mr. J. Chester Bradley for their untiring efforts in arranging for the entomologists' tours to the International Congress of Entomologists at Paris, and to other European points of interest during the past summer; and

3—To Mr. T. J. Headlee and Mr. C. H Hadley for their efforts in making the admirable local arrangements which have contributed so much to the success of this meeting.

Respectfully submitted,
H. E. HODGKISS
C. R. CUTRIGHT
B. A. PORTER

Upon motion regularly made and seconded, it was voted that the report be adopted.

CHAIRMAN H. E. HODGKISS: "The following resolution was received from the Section of Extension, and after due consideration is reported to this body as submitted:

Owing to an increasing need for information on the performance of apparently new insecticides which enter the market each year; to the reduction of funds for economic entomological work, and to the fact that the federal authorities charged with the enforcement of the Federal Insecticide Act, necessarily, in the course of their work accumulate much of this needed information; be it

Resolved, That the said organization doing this work should be requested by this Association to establish a regular and full publication of its significant results, and distribute the same promptly and regularly to all working economic entomologists in this country, and in Canada."

H. E. Hodgkiss
C. R. Cutright
For the Committee

The motion to adopt this resolution was proposed, put to a vote and carried.

REPORT OF THE COMMITTEE ON MEMBERSHIP

Part I

(1) Recommendations for Associate Membership—50 names.

The list is as follows:

Anderson, L. D.
Baker, W. C.
Baumhofer, L. G.
Berman, H. D.
Birdsall, R. W.
Blanton, F. S.
Buckner, R. P.
Collins, D. L.
Daniels, L. B.
Dickison, Wm.
Doner, M. H.
Dorman, R.
Gould, E.
Griffin, S. W.
Guy, H. G.
Haydak, M. H.
Henkels, R. M.
Jones, L. S.
Jones, M. L.
Kessler, K. L.
Kutchka, G. M.
Mathes, R.
Maughan, F. B.
Millender, H. C.
Miller, F. W.
Morrison, H. E.
Morton, F. A.
Munger, F.
Murphy, D. F
Newton, R. C.
Riley, M. K.
Roaf, J. R.
Schmitt, John B.
Shields, S. E
Simpson, G. W.
Smith, C. L.
Smith, F. A
Soudek, Stepan
Spawn, G. B.
Spies, J. R.
Stage, H. H.
Thompson, B. T
Thompson, G. A.
Tibbetts, H. A.
Walker, G. L.
Westgate, W. A.
Wilcoxon, F.
Wilford, B. H.
Willard, H. J.
Wygant, N. D.

(2) Recommendations for advancement from Associate to Active Membership—44 names.

Allen, Norman
Barnes, O. L
Beal, J. A.
Beutenmuller, W.
Bissell, T. L.
Brown, R. C.
Bruce, W. G.
Chamberlin, J. C.
Coleman, W.
Cressman, A. W.
Davis, E. G.
Ditman, L. P.
Ebeling, W.
Emery, W. T.
Farrar, C. L.
Filmer, R. S.
Frankenfeld, J. C.
Fulton, R. A.
Glover, L. C.
Gould, G. E.
Grimes, D. W.
Hall, R. C.
Herr, E. A.
Hinman, F. G.
Hodgson, B. E.
Kellogg, C. R.
Latta, R.
Marshall, G. E.
Martin, C. H.
McAlister, L. C.
Moreland, R. W.
Oertel, E.
Richardson, H. H
Richmond, R. G.
Roberts, R. A.
Salman, K. A.
Shepard, H. H
Shull, W. E.
Smith, C. M.
Smith, L. M.
Stickney, F. S.
Struble, G. R.
Wall, R. E.
Watson, J. R.

(3) The Committee recommends the following three men:—J. I. Hambleton, W. H. White, and F. D. Butcher, be reinstated in the Association, and in the class of membership they were in at the time they were dropped.

(4) There are six resignations as follows:

DeCoursey, R. M.	Fisher, W. S	Couch, O. E.
Prevost, E. S.	Light, S. F.	Salt, R. W.

(5) Because of unusual financial conditions presented by two active members, the Committee recommends that their membership fee of $1.50 be remitted for one year.

ALVAH PETERSON, *Chairman*
L. B. SMITH
W. H. LARRIMER

Voted that this portion of the report be adopted.

PART II

CHAIRMAN PETERSON: I might say that it is a difficult task for a membership committee to determine the transfers from the associate to the active list. No two membership committees have the same standard, no two members have the same standard, and it is extremely difficult to make that determination.

Because of that, and a number of other reasons, we want to present the following recommendation:

That the President appoint a committee of three or direct the standing Membership Committee to study the classes of membership in the Association with the idea of possibly combining the present associate and active membership, or recommending specifications more clearly defining qualifications for the present classes of membership, and submit a report at the next Annual Meeting.

ALVAH PETERSON, *Chairman*
L. B. SMITH
W. H. LARRIMER

Voted to adopt this part of the report.

Mr. M. D. Leonard made the suggestion that the present membership list of the Association be given critical examination with a view to a possible rearrangement in some cases, (particularly of members in foreign countries), which would more accurately group the members in their proper classification.

Discussion by Messrs. Felt and Burgess supported this recommendation and pointed out the advisability of such action and further, that it would be preferable to detail the conduct of such an investigation to the Standing Committee on Membership than to a special Committee.

It was voted to adopt this recommendation and that the investigation be conducted by the Membership Committee.

NOMINATION OF JOURNAL OFFICERS BY THE ADVISORY COMMITTEE

Mr. H. B. Weiss, *Chairman:* "The Advisory Committee makes the following nominations for Journal Officers:

For Editor—E. P. Felt.
Associate Editor—D. M. DeLong
For Business Manager—A. I. Bourne

Upon motion regularly made and seconded, it was voted that the three gentlemen listed above be elected as Journal Officers for the ensuing year. They were so elected.

REPORT OF THE COMMITTEE ON NOMINATIONS

Your committee reports as follows:

President: W. E. Hinds.
First Vice-President: R. H. Pettit.
Vice-Presidents: (Pacific Slope Branch)—R. L. Webster.
(Cotton States Branch)—J. W. Folsom.
(Eastern Branch)—T. J. Headlee.
(Section of Plant Quarantine and Inspection)—R. W. Leiby.
(Section of Apiculture)—W. E. Britton.
(Section of Extension)—H. E. Hodgkiss
Secretary: A. I. Bourne for 3 years.

Standing Committees

Executive Committee for three years: Two years—W. P. Flint
J. M. Swaine.
Membership Committee for three years:
P. W. Claassen.
Advisory Board, Journal of Economic Entomology for three years:
W. H. Brittain.
C. A. Weigel.
Committee on Insect Collections for three years:
T. H. Frison.
H. M. Harris.
Committee on Research Work on the Control of the European Corn Borer: for five years:
D. J. Caffery
Board of Trustees of Permanent Fund for three years:
A. F. Burgess.
Advisory Representative of Group 8 of the National Research Council for two years:
W. A. Riley.
J. E. Graf (Alternate)

The record shows they were elected for one year, the term to expire this year, but Dr. Lutz tells us they should have been elected last year for a three-year period. We took his advice and have renominated them for a two-year period.

It is an organization that we are all interested in and we all have good reason to be proud of it It has accomplished a great deal during the years it has been in existence. It is a going concern, sound financially and has a creditable record. The Executive Committee of the Association has had under consideration some ideas in regard to the future of the organization and possible greater development, and from time to time will undoubtedly report on the matter.

We are living in days of depression We are living today at a time when some of our members are out of work What the future may be, no one knows, but I think we may be hopeful, and I think we should plan at this time confidently for the future in order to make this Association more valuable than it has ever been before

In order to bring this about, we need, as I see it, more cooperation and teamwork among the entomologists themselves I am not saying that in a spirit of criticism, but when you start to look over the field, you soon find if you take all the entomologists there are in this country, that they are a relatively small group compared with many of the other scientific organizations

There are serious entomological problems ahead We should have the best possible teamwork I don't think the entomologists can afford to divide their time or divide their allegiance. They should all pull together for a common purpose That is the building up and development of entomology.

I had in mind a number of times saying something of this sort to the Association when we come together, but it has always seemed as though there never was enough time to do it. It has always seemed as though at the last session when it was about time for the curtain to ring down, everyone was anxious to get away.

So, I am taking advantage of this opportunity tonight so that I hope some of the members here will take some of these thoughts away with them as they go home, and if there is any way in which they can increase the influence of the standing of entomology, they will take advantage of the opportunity to do so.

I notice from the report that was given that I was elected a member of the Board of Trustees of the Permanent Fund. I have been on that Board before. I have done my share of struggling before the Board was created to attempt to have the Association amply financed and to attempt to accumulate a fund for the Association for future development, or for any unforeseen emergencies that might come about. I hope that fund may be increased.

We have a Committee on Endowment, and I believe that committee

can work and will work when more concrete plans are worked out by the Executive Committee. If you have any influence among some of the (this is just one line of thought) good people who have more worldly goods than they know what to do with, or more than they can take away with them when they go, some fraction of that might be helpful to the Association.

From a conversation with a gentleman the other day, I understand there was recently given some society, a million dollars. That does not sound like very much when you say it quickly, but it is quite a lot. There are undoubtedly people who would help if they understood our needs and if the proposition were presented to them by someone who has their confidence

I want to say two or three words about this meeting. I think this meeting has been particularly successful and unique in several respects, and that our retiring President, Professor Flint, has reason to be very proud of this meeting that has been held here. I cannot see how he can take away with him when he goes home, anything but pleasant memories in regard to his year of presidency of this Association.

We all appreciate what he has done We all appreciate the work that the local committee did in arranging for this meeting place and the conveniences we have had here. I do not recall any meeting where we have had as good a meeting room, as good accommodations, as we have at this meeting, and I think the dinner that was held last night will compare favorably with any we have ever had. It was most interesting and most inspiring to hear from the lips of our own members the information that they brought from the countries they had visited all over the world.

I feel that this meeting has been a very great success. (Applause)

The question of forming a special class of members composed of undergraduate students in Entomology, was discussed by Mr. C. H. Richardson with the suggestion that this be considered by the Association for later action.

Mr. Felt: We have heard something in numerous meetings in regard to the value of discussion and yet we are consistently meeting, year after year, and the men appear on the platform and present a proposition, frequently a technical one, with practically no prior indication as to the subject matter. We expect the audience to discuss those papers intelligently. It just cannot be done.

We started a few years ago with the Secretary requesting an abstract of papers to be submitted. Those abstracts consisted of three or four lines and practically gave no indication of what is going to be presented

in the paper. There are scientific organizations which insist upon a reasonably good abstract.

I am not for a moment suggesting that every individual in this entire group would discuss every paper, but I am suggesting this: That if we could have really comprehensive abstracts published in the program so that the men coming here would have a fairly good idea of the propositions the various participants upon the program are going to present, we would be in a much better position to discuss them intelligently and as an organization, we would get a great deal more out of it.

I had occasion to go to one or two other meetings. I have before me abstracts published in the American Journal of Botany. Those abstracts run about a half page each. They give a fairly concrete idea of the thesis the individual is proposing or that he plans to defend. Were we to have abstracts in relation to subjects in which I was especially interested, I would certainly find time before coming to the meeting to look up and participate, possibly disagree, good-naturedly, with the man presenting the paper.

I would like to suggest (I do not care to make a motion) that the Secretary ask the men who contribute to the program next year to provide an abstract, one that will give a real idea of what each individual paper is likely to contain

By vote of the Association an expression of sympathy was sent to Professor P. A. Glenn of Urbana, Illinois, who had been seriously injured in a recent automobile accident, and a message of greeting was forwarded to Dr. L. O. Howard in Washington.

Mr. Burgess voiced the appreciation of the Association for the long period of able and faithful service rendered by Dr. E. P. Felt who had just completed a quarter of a century as Editor of the Journal and who had consented to continue in that capacity another year.

It was voted that the next annual meeting be held at the same time and place as that of the American Association for the Advancement of Science which is scheduled to be held in Boston, December 26–29, 1933.

The 45th Annual Meeting of the American Association of Economic Entomologists was then declared adjourned.

PART II. PAPERS AND DISCUSSIONS

PRESIDENTIAL ADDRESS

Balancing the Entomological Program

By W. P. FLINT, *Urbana, Ill.*

All of us who are dealing with the problems of insect control on livestock, grain, fruit, truck farms, greenhouses, or in other branches of agriculture have many times considered the outlining of a balanced program of production that would give the proper amount of emphasis to measures for the control of insects In other words, we have considered the balancing of an agricultural program in such a way that the measures for insect control and the improvement of crop quality and marketability through insect suppression can be applied most efficiently. To put it still another way, we have tried to work out a program which will call for the amount of work necessary to prevent insect damage without over- or under-emphasizing any particular phase of production effort.

As the work of the Experiment Stations has grown and developed, a point has been reached in practically all states where serious consideration is being given to a unified, balanced farm program, including not only the most economical methods of production, but the best way of producing quality products and the marketing of these products. While we think of insect control as applying primarily to quantity production, we must not lose sight of the fact that the control of insects is equally or more important in the matter of quality and in the marketing end.

There is, generally speaking, no profit in insect damaged goods. Such products can sometimes be sold but always at a low price. No one wants to buy weevily wheat, earworm infested corn, or wormy apples. Such products can be sold only at a price much below that of uninfested products, or at times when the supply is limited. The cost of production of such inferior stuff is nearly equal to that of first quality products and the cost of marketing is higher.

Many of us have, time and again, seen instances where insect outbreaks of varying degrees of intensity have occurred but where the owner or manager of the farm, grain elevator, greenhouse range, or other production unit has started control measures too large or on too extensive a scale to permit his actually obtaining a profit on the operation. More frequently we have seen the reverse of the above, that is, the incipient development of an insect outbreak where it has been felt that something would turn up to control the insects, and the insects have been permitted to develop to such an extent that an entire crop has been

destroyed. There is a half-way line between these two which we as economic entomologists should be able to point out.

In the present agricultural situation there is an intense effort on the part of all farm operators to reduce the cost of production to the lowest point possible. During the past two years in the Middle West it has been impossible in many cases to reduce cost of production to a point as low as the price received for the product. Under these conditions we find an increased amount of interest in the work of the Experiment Stations, with a strongly expressed desire on the part of the farm owners and operators for a balanced program for the production of every farm product. The producers wish to know the best methods for producing quality products which will meet the demands of the market, and they wish these methods to include all production factors, such as type of soil on which the crop should be grown, the proper fertilizer, cultural practices, methods of controlling insects and diseases, harvesting methods, preparation for and marketing of the crop. In addition to all this, he wishes to know as nearly as possible the amount of effort that should be given to each of the factors for a given year. The farmer or farm manager wishes this information and he does not care in the least whether he secures it from the department of agronomy, zoology, astronomy, higher mathematics, or entomology. He wants the information. He wants it in such a form that he can use it, and he wants to know how much effort and expense can be profitably devoted to this or that phase of production and still produce quality products which, under anything like normal conditions, will allow him reasonable returns on his investment and cost of production

It seems quite certain that much of the effort of the Experiment Stations during the next ten years will be directed towards the working out of such programs. One might say that most of the effort of the stations in the past has been directed towards the same object. This, of course, is true but there is at the present time a much more well-defined, definite effort directed towards the working out of well-balanced production and marketing programs which will include the results of all scientific research.

No attempt is here made to specify any set rules by which such a well-balanced entomological program can be worked out. This is only an attempt to call attention to a few of the factors that must be considered in making up such a program, with the hope of suggesting better methods and ways of doing it.

In the first place, it is absolutely essential that the entomologist in making up his program consult and cooperate to the fullest extent with

all other departments whose work may affect the same production program and, equally important, with his fellow entomologists. The entomological program can be balanced only by as full knowledge as possible of the needs in other lines of work and a careful and unbiased consideration of the relative importance of the different factors to be stressed by the farm manager or owner in his program. The program must be considered from the standpoint of the entire unit for which it is made, be that unit a county, state, or special crop area. We may consider the crops of the area according to their value, the insects that are likely to injure them, the probability of damage by each insect and the amount that can possibly be expended for a profitable control in relation to the return from the crop.

As an example, in most of the large mid-western states the major field crops consist of corn, winter and spring wheat, soybeans, oats, barley, rye, white potatoes, sweet potatoes, timothy, clover, alfalfa, and a few others of less importance. The total value of these field crops in Illinois at the present low level of prices is approximately $250,000,000 annually. The value for the year 1930 was $291,000,000. The major orchard crops of that state, that is, the apples, peaches, pears and grapes, have a present value of around $12,000,000 and the small fruits add a possible $2,000,000 or more to the total value of the fruit crop. The value of Illinois truck crops has been estimated to be approximately $20,000,000 and that of greenhouse crops at approximately $22,000,000. Based on the above figures alone, we would say that we should devote approximately one-sixth of our time to the control of insects infesting greenhouse, truck and orchard crops, and five-sixths of the time to the insects infesting field crops. On a basis of crop values alone, this would be a reasonable division of time, but certainly no entomologist would consider that a program where the time of the entomological staff was divided in the above way was a sound one, or a well-balanced one.

Aside from the value of the crops, we must take into consideration the insect hazard of each class of crops as a whole, and specifically for each special crop. We must also consider the effectiveness of our control measures and from this obtain the amount of time which could be profitably used in a production program for that crop. We should also consider the possibility of producing the crop without giving any special attention to the matter of insect control. Such is often the case with certain field crops but seldom the case with orchard, truck and greenhouse crops. The present day market demands nearly perfect products in vegetables, fruits and flowers, but is not so particular in regard to the field crops that are nearly all processed or fed to livestock.

Several years ago the writer made an attempt to estimate the insect hazard for some of the major crops grown in Illinois. Several different methods were used in trying to arrive at an estimate of the insect hazard. It was decided that the actual amount of loss which occurred on the average Illinois farm in a normal year could be considered as the insect hazard for that particular crop for an average year, or in other words, the insects would normally destroy that amount of the crop on the average farm. The amount destroyed, or the hazard on the poorer managed farms would be much higher and that on the best farms less. On the above basis it was estimated that the insect hazard was for:

Corn, approximately	9%
Wheat, practically the same, or	9%
Rye	4%
Oats	5%
Barley, northern and central Illinois	4%
Barley, southern Illinois	18%*
Sudan Grass	4%
Timothy	7%
Blue Grass	11%
Alfalfa	8%
Red Clover	14%
Red Clover Seed	28%
Sweet Clover	6%
Soybeans	4%
Irish Potatoes	15%

*As a matter of fact, barley is not grown as far south in Illinois as it is climatically possible to grow it, largely because it is so severely damaged by chinch bugs if grown in the southern one-fourth of the state.

Of the three most important fruit crops, the per cent actually destroyed was approximately for:

Apples	25%
Peaches	25%
Pears	20%*

*As an explanation of the low per cent of damage to pears it should be said that the Keiffer pear is practically the only one that can be grown commercially in Illinois because of severe blight damage to other varieties. The Keiffer pear is not very subject to insect injury.

The figures just given are an estimate of what does happen on the average farm. A careful consideration of the reduction that could be effected in insect damage to the corn crop by applying the best methods of controlling the various corn insects would show that the present loss of 9 per cent could be nearly cut in half, or a saving of 4 per cent of the corn crop might be effected with only a very slight increase in the cost of production of this crop. It would seem from this that we could work out a balanced production program on the basis of the above figures after a thoro consideration of the whole production program of field crops. Such a program, however, would not be balanced for a given year and the

amount of time which could be devoted to insect control would not be properly allotted if any one of the 20 or 25 more destructive corn insects were present in more than usual numbers, or occurred in what we usually term "outbreak numbers." While the actual average loss from all insects to the corn crop over a 20 year period would amount to only about 9 per cent, there are at least 15 to 20 insects which are always present in the corn belt, and which, under certain conditions, may destroy 100 per cent of the crop on a given farm, or over a considerable area It is absolutely essential then, in balancing our program, that we know whether or not any of the more important insects of the crops we are considering are likely to be more than normally abundant. If such is the case, the corn grower may find it best, for the time being, to pay little heed to the matter of soil improvement, variety development, or other matters in his production program and place more than the usual amount of his production effort on the control of a certain insect or insects. Under such conditions it would perhaps be necessary for him to spend 25 per cent or more of his production cost and effort on the control of insects because if the insects are not controlled, no crop whatever will be raised. With due consideration of this factor, it would certainly seem important in building any production program in which the economic entomologist takes part, that he have all of the advance information possible on the relative abundance of the more important insects within the area where the program will be used. It is also very important that the entomologist know whether there is a likelihood of any new insects appearing in the area, such as the invasion or introduction into the area of any foreign insect pest. If the abnormal abundance of any insect can be predicted, the cost of control can be lessened and its efficiency greatly increased. All this brings out the importance of frequent surveys and obtaining information from all other sources that will help the entomologist to keep fully informed on the insect developments in the region in which he is working.

There are still a number of other factors to be considered in a production program such as the one we have been outlining. In the case of any insect we must know not only the amount of damage which it is capable of inflicting but also the degree of control which can reasonably be expected by the application of practical control measures. The corn ear worm in certain years destroys as much as 4 or 5 per cent of the central Illinois corn crop, but with our present methods of control it is hardly practical to make any expenditure of time, effort or money in attempting to reduce this damage. On the other hand, the northern corn rootworm is perhaps, all in all, the most seriously de-

structive corn insect which occurs in this same area, that is, it will destroy a larger percentage of the corn crop over a 20-year period than may be the case with any other insect. We have a practical control for this insect which is nearly 100 per cent efficient and this method should be used in any corn production program.

In building up a balanced program from the standpoint of the entomologist, it is highly important, as pointed out by Sherman in his presidential address at Cleveland, Ohio, in 1931, that the entomologist as frequently as possible take an insect census of the region where he is working. It is equally important to know the possibilities of each insect and the factors affecting its abundance each year, or what effect these factors have had during the past season and the influence they will be likely to exert on insect abundance during the coming year. With the above considerations of the purely insect side of the problem, one must, if he is to work out a program which will be of greatest assistance to the farmer, carefully consult with the representatives of other departments of the work and balance the program accordingly.

We can never hope to bring out the full importance of our work in economic entomology unless we consider this work in its relation to the whole farm program. We must advocate only those control measures which should, in such a balanced program, produce increased returns in crops or money value of crops without over-emphasis on the insect control factors.

We are now in a period where our work will be more closely scrutinized and criticized than at any time during the lifetime of most of us. We must have a coordinated program which will call for the closest cooperation by all branches of our entomological work with all other departments of the institutions where we are working. Also, to a greater extent than ever before, inter-institutional cooperation is demanded.

Chairman Phillips: It has been a very interesting thing to all of us, I am sure, to hear this discussion in which the economics of entomology has been so ably stressed by our President.

Dr. Bishopp: I would just like to say a word with reference to the splendid way in which this subject has been covered by our President. He is to be congratulated. I feel a little sorry, however, with five-sixths of the entomologists devoted to fruit and work along other agricultural lines, that we could not have found another three-sixths to devote to medical entomology.

We never lose an opportunity to bring to the attention of economic entomologists the thought that this field of medical entomology in

America is being sadly neglected. We must recognize the fact that we have a billion-dollar poultry industry in this country, a live stock industry of tremendous value, and that to man and his family are due some consideration by the entomologists.

We feel we are very much remiss in our duties if we do not more fully occupy this very interesting and exceedingly important field of economic entomology.

DR. O'KANE: I should like to say two or three words to express what I believe is the feeling of all the rest of us here. It is a good thing to have a man like President Flint. It is a good thing to have a man who can look at this subject with a quiet, well-balanced, judicial mind, as he has. Any of us who have worked with him know that he always keeps his feet on the ground, and yet maintains a scientific attitude toward his work and a way of looking into the future that some of us forget about sometimes

OBSERVATIONS ON SHADE TREE INSECTS

By E. P. FELT, *Bartlett Tree Research Laboratories, Stamford, Conn.*

ABSTRACT

The elm leaf beetle, *Galerucella xanthomelaena*, the Japanese beetle, ***Popillia japonica***, the willow leaf beetle, ***Plagiodera versicolora***, and the larch case bearer, ***Coleophora laricella***, were all abundant and possibly as destructive as in 1931. The occurrence of many parasites, ***Scolia dubia***, on a lawn badly injured by the Japanese beetle and the green June beetle, ***Allorhina nitida***, is recorded. Notes are given on the cypress leaf miner, ***Recurvaria apicitripunctella***, a leaf beetle, ***Calligrapha philadelphica***, a privet thrips, ***Dendrothrips ornatus***, and the black vine weevil, ***Brachyrhinus sulcatus***. The two-lined chestnut borer, ***Agrilus bilineatus***, and the bronze birch borer, ***Agrilus anxius***, were killing trees locally. They were probably favored by the series of droughts in recent years. A bad infestation of rhododendron stems by the pitted ambrosia beetle, ***Corthylus punctatissimus***, is recorded from Long Island, and the local prevalence of the leopard moth, ***Zeuzera pyrina***, on Nantucket Island is reported. The oak pruner, ***Hypermallus villosus***, has been extraordinarily abundant in the northeastern United States. The fruit tree bark beetle, ***Scolytus rugulosus***, and the European elm bark beetle, ***Scolytus multistriatus***, have developed in great numbers on weak trees. The European pine shoot moth, ***Rhyacionia buoliana***, continues as a destructive pest, and the Nantucket pine moth, ***Rhyacionia frustrana***, has been extremely abundant on Nantucket Island. The recently discovered white pine tip moth, ***Eucosma gloriola***, is becoming somewhat widely distributed, though not seriously injurious. The unusual local abundance of the pitch mass borer, ***Parharmonia pini***, was observed at Bedford Hills, N. Y. The elm lace bug, ***Corythucha ulmi***, and the sycamore lace bug, ***Corythucha ciliata***, have been unusually prevalent, and the work of the linden lace bug, ***Gargaphia tiliae***, came to notice on account of its abundance at Stockbridge, Mass. An elm pouch gall, ***Eriophyes*** sp., was very num-

erous on elms at Wakefield and Lynnfield, Mass., and the maple bladder gall, *Phyllocoptes quadripes*, was extremely abundant on a soft maple at Newburgh, N. Y. The tulip tree scale, *Toumeyella liriodendri*, was quite prevalent, though it was preyed upon locally by the caterpillars of *Laetilia coccidivora*. The Euonymus scale, *Chionaspis euonymi*, has been extremely numerous in various plantings. A new hemlock leaf scale, *Fiorinia*, near *F. fioriniae* Kuwana, is becoming established and injurious at several Long Island and southwestern New England localities. The Chinese mantid, *Paratenodera sinensis*, has been unusually abundant in southwestern New England and southeastern New York.

The four important leaf eaters of last year, namely the elm leaf beetle, the Japanese beetle, the willow leaf beetle and the larch case bearer, were very much in evidence the past season.

There was a time in early July when it seemed possible that the elm leaf beetle, *Galerucella xanthomelaena*, would not be as destructive as the preceding year. Subsequent developments indicated that this was due in large measure to earlier cool weather hindering development, and by the middle to the latter part of August there was abundant evidence of serious injury. It is quite possible that the damage not only in New England but in New York State at least, approximated that of 1931.

The Japanese beetle, *Popillia japonica*, approximated, if it did not exceed, the defoliation record of the preceding year, and the discovery of the pest last summer by the Bureau of Plant Quarantine in 143 new localities in States partly covered by quarantine and the finding of it in eight additional States, a total of seventeen infested States in addition to the District of Columbia, can have but one meaning, namely, that there has been a material extension of the infested area and that these new, many widely separated localities are centers from which there will be additional spread. In the course of a few years we may expect much more general damage by this pest to shade trees.

The past summer specimens of a Scoliid, *Scolia dubia*, were reported as occurring by the hundreds flying over a lawn in the environs of Philadelphia badly infested with grubs of both the Japanese beetle, *Popillia japonica*, and the green June beetle, *Allorhina nitida*. It is possible that this enemy of native white grubs is learning to include the larvae of the Japanese beetle in its menu.

The willow leaf beetle, *Plagiodera versicolora*, injury appears to have caused more damage than last year and there probably has been an appreciable extension of the infested area, though we have no data upon this. The situation has not been helped, so far as the willows are concerned, by the ravages of the recently introduced willow scab fungus.

The larch case bearer, *Coleophora laricella*, does not appear to have been quite so abundant as in 1931, in various southern New England

localities, though it was reported as practically defoliating larch in the Adirondacks and northern New England

The depredations of these widespread introduced leaf eating insects are a real threat to the well being of shade trees in the northeastern United States, especially as in the ordinary course of events we may expect greater rather than less damage in the future unless the situation is helped by more general, systematic spraying. This is particularly true of the more destructive introduced pests. The recent discovery of a large gipsy moth, *Porthetria dispar*, colony in northeastern Pennsylvania is certainly disquieting because this insect, although well controlled in recent years, is potentially a very serious pest of shade trees as well as a menace to forest areas. This new infestation threatens the existence of the Barrier Zone itself, a barrier line which has been maintained most effectively for nine years

The cypress leaf miner, *Recurvaria apicitripunctella*, has attracted notice the last few years by its depredations upon individual bald cypress trees in southwestern New England and southeastern New York. The larvae were so numerous upon individual, isolated trees as to practically prevent the development of the foliage this past season. A similar injury came to notice in eastern New England.

A leaf beetle, *Calligrapha philadelphica*, was brought to notice through Dr. B. O. Dodge of the Bronx Botanical Garden, on account of its feeding abundantly on the foliage of the silky dogwood, *Cornus amomum* in the Bronx River Parkway near the Mount Vernon Railroad Station.

A comparatively unknown privet thrips, *Dendrothrips ornatus*, has been observed in moderate numbers at Mamaroneck, N.Y., Stamford and Fairfield, Conn., and Melrose and Ipswich, Mass It is evident that this introduced species is somewhat widely distributed, although on account of its minute size and the inconspicuous character of the injury, it is ordinarily overlooked.

The black vine weevil, *Brachyrhinus sulcatus*, continues abundant in southern New England at least, and attracts notice because of its depredations upon yew or Taxus. Infested plants show unhealthy branches and yellowish or browning foliage.

The two somewhat common cambium borers, namely the two-lined chestnut borer, *Agrilus bilineatus*, and the bronze birch borer, *Agrilus anxius*, were locally abundant, killing trees. This was particularly the case with the former, probably because the ornamental birches have been so generally killed that there are relatively few to support the bronze birch borer.

The pitted ambrosia beetle, *Corthylus punctatissimus*, was reported

the past season from several southern New England localities, and in one case on Long Island it was stated that a group of 300 rhododendrons showed practically every stem infested, in some instances so severely that the stems had to be cut out.

The leopard moth, *Zeuzera pyrina*, was found well established in one Nantucket Island locality, the magnificent elms being very badly infested. This condition led to a series of tests with a new borer remedy known as Bor-Tox, and since the initial tests gave very satisfactory results, this was used upon the infestation with generally gratifying results. It is only necessary to inject a little of the material into inhabited galleries and the caterpillar kindly does the rest by getting into the paste as it attempts to clean its gallery.

The oak pruner, *Hypermallus villosus*, has been extraordinarily abundant in southern New England and southeastern New York, including Long Island. A specific report of the general prevalence of this insect on Martha's Vineyard, Mass. was received, and personal observations, as well as numerous complaints, showed that this borer was very abundant. In some cases 50 or 100 twigs might be cut off a single tree

Invasions of recently transplanted trees by the fruit tree bark beetle, *Scolytus rugulosus*, have been unusually numerous. In one case good sized apple trees were attacked by so many of these little borers that speedy death would have resulted had not remedial measures been promptly adopted. A large proportion of the insects were killed by wrapping the infested areas with burlap and then spraying with a 1% summer oil and nicotine at the usual strength. This was done as soon as the attack came to notice and many of the beetles still at work upon the main galleries were destroyed.

The European elm bark beetle, *Scolytus multistriatus*, appears to have been somewhat generally established in southwestern New England, southeastern New York, New Jersey and near Philadelphia, Pa. We have records of its occurrence at Stamford, Conn. and the Bronx Parkway, Westchester County, N. Y., at Orange and Princeton, N. J. and at Sunbury, near Philadelphia in Pennsylvania. It appears to be limited largely if not entirely to sickly trees or parts of trees, and in the case of the Princeton infestation, it was confined to one large branch. Cutting that off and burning the wood resulted in freeing the tree from the pest. Like the fruit tree bark beetle, *Scolytus rugulosus*, it may attack and kill most of a weak tree toward the end of a season.

The European pine shoot moth, *Rhyacionia buoliana*, is widely distributed and here and there becomes so destructive that most if not all of the shoots of even good-sized plantings may become infested. Spray-

ing the latter part of June with a 2% summer oil, nicotine and arsenate of lead, and giving a second treatment a week later has resulted in a reasonably satisfactory control.

The Nantucket pine moth, *Rhyacionia frustrana*, is locally very abundant on the pines on Nantucket Island, adults issuing the middle of May It was reported by Mr W. G. Aborn of Providence that up to about four years ago the scrub pines on Nantucket Island were doing very well, but since then this pest has been creating havoc, the badly infested trees appearing very much as though they had been killed by fire. Last July, somewhat to our surprise, a small planting of ornamental pine in the environs of Philadelphia, was found so badly infested by the larva of this species that practically every shoot was killed back for a distance of two to three inches.

The newly discovered white pine tip moth, *Eucosma gloriola*, continues prevalent on white pines at North Stamford and has been reported from Greenwich, Conn. It has not developed in sufficient numbers so that it can be recorded as a serious pest.

The pitch mass borer, *Parharmonia pini*, was found unusually prevalent in a grove of white pines at Bedford Hills, N. Y. A considerable percentage of the trees showed one to several pitch masses resulting from the work of this borer

The season of 1932 appears to have been unusually favorable for the development of lace bugs. The elm lace bug, *Corythucha ulmi*, was extremely abundant upon American elms growing in wild or weedy areas between Kent and Canaan, Conn., a distance of some 40 miles, and was also reported as injurious at Amenia, N. Y. The insects produce a somewhat general characteristic yellowish discoloration of the leaves, which frequently affects a considerable proportion of the foliage. It appears to be confined to trees growing along fence rows and other places where there is excellent winter shelter.

The related sycamore lace bug, *Corythucha ciliata*, was also extremely abundant and injurious in late summer throughout much of southwestern New England and southeastern New York, the foliage on sycamore sprouts being especially favored and rather generally discolored, the areas at the base of the leaves being most severely affected.

The linden lace bug, *Gargaphia tiliae*, was so abundant on certain trees at Stockbridge, Mass , that the leaves showed a general discoloration and browning and were practically functionless. The insect itself, with its two well defined white lines, is one of the most beautiful representatives of this particular group.

An elm pouch gall, *Eriophyes* sp , was reported as extremely abundant

on elms at Wakefield and Lynnfield, Mass. The leaves were literally crowded with somewhat curved, fusiform galls about a quarter of an inch long Another mite gall on elm, presumably the work of another species, was reported as abundant at Wilton, N. Y.

The maple bladder gall, *Phyllocoptes quadripes*, was found extremely abundant on a soft maple at Newburgh, N. Y, the infested leaves being presumably nearly functionless, owing to the multitude of tiny galls. A similar condition was observed the year before at Lenox, Mass., and in this latter case the trees were presumably injured by the abundant mite infestation, although they were also suffering from malnutrition.

The tulip tree scale, *Toumeyella liriodendri*, continues to be somewhat abundant It is interesting to note that an artificial infestation on young trees started in 1930 has resulted in an abundant production of the scale insects to such an extent that considerable proportions of the branches became infested in the fall of 1931 Last August a very considerable proportion of the underside of the infested twigs was literally covered with nearly full grown scale insects At that time numerous wasps, hornets and flies were attracted to the abundant exudation as well as many ants This new colony also proved attractive to the predaceous caterpillars of *Laetilia coccidivora*, and it is a source of regret that these beneficial insects were unable to bring about a satisfactory control of this pest.

The Euonymus scale, *Chionaspis euonymi*, continues to be abundant here and there The control is a real problem, owing to the insect producing three generations in a season and the difficulty of spraying so thoroughly as to actually kill all the insects upon the plant Our best results have been secured by dormant oil applications, and although these take off the foliage, no injury results, since the leaves always drop in the spring.

The hemlock leaf scale, *Fiorinia*, near *F. fioriniae* Kuwana, is known to occur at several Long Island localities, namely Brookville and Oyster Bay. It has also been found on fir and hemlock at Greenwich, Conn. This insect, we are advised by Dr. Harold Morrison, in charge of Taxonomic Investigations of the Federal Bureau of Entomology, is identical with material from the eastern United States determined a few years ago as *F. fioriniae* var. *japonica*, though Dr. Morrison is now of the opinion that it is distinct from this species, and adds that it is probable that the true *Fiorinia japonica*, does not occur in the United States and that all records purporting to be this species actually refer to the insect we have found abundant on hemlock in several Long Island localities and at Greenwich, Conn. In one case a good sized hemlock some 50 feet high

had most of the underside of the foliage almost covered with the variable purplish-brown, yellow-marked females frequently dusted with white and the yellowish young. The infestation was so general that if allowed to persist it must seriously affect the vitality of the tree. A much more sparse infestation was found upon spruce. Spraying in late fall with a 2% summer oil and nicotine resulted in a very satisfactory kill. This insect may prove to be a somewhat serious enemy of ornamental hemlocks.

The Chinese mantid, *Paratenodera sinensis*, has apparently become rather well established in southwestern New England. Several specimens were taken in the City of Stamford and the same is also true of Danbury. Reports this summer indicate that these large insects were also found in the heart of New York City. Egg masses were obtained by Mr. S. W. Bromley in 1930 and planted at North Stamford, Conn. It is possible that we owe the local abundance of the insect to this introduction, though the general occurrence of this insect at Danbury and its being observed at New Haven suggests that some more general agency may have been responsible for the rather widespread occurrence of this insect in southern Connecticut.

A METHOD OF DETERMINING LOSSES TO FORESTS CAUSED BY DEFOLIATION

By J. N. Summers and A. F. Burgess

Abstract

A brief discussion of the problem and the development of a formula.

The determination of the actual loss resulting from the defoliation of forest trees by insects is a perplexing problem. Unquestionably such loss does result but unless a definite monetary value can be assigned, it is impossible to ascertain the extent to which expenditures for control are justified.

Detailed investigations conducted over a period of years in connection with the control of the gipsy moth have shown conclusively that defoliation does have a detrimental effect on trees and that this effect is in proportion to the degree of defoliation suffered. Complete or nearly complete defoliation, particularly if repeated for several years, results in the death of the trees, the rapidity of death depending to some extent on the vitality of the trees, the time when defoliated, and the supply of moisture after defoliation. The loss resulting from the death of trees is only a part of the damage caused by insect feeding, as those trees which are not defoliated sufficiently to cause death may nevertheless suffer

considerable loss in growth. This loss is not evident to the casual observer but can be determined by accurate measurements. For this reason it is apt to be considered that the death of trees is the only injury resulting from defoliation As growth and the maintenance of full tree vigor depend upon full foliage it is very evident that the removal of any part of the leaf surface must have its effect. The decrease in growth occasioned by defoliation has been demonstrated conclusively in connection with gipsy moth field study, as recorded by Minott and Guild.[1] Careful measurements of annular rings have shown that annual growth is decreased by the removal of the foliage and that this decrease varies directly with the degree of defoliation, in almost constant proportion.

For all tree growth defoliated by insects we have, therefore, two types of loss; i. e., that through death and that through decrease in growth, and in determining the economic status of the insect responsible, both must be considered. Because of wide variation in size of trees, potential yields, value of products and available markets, it is difficult to determine monetary loss on the basis of the stumpage values of lumber. It is possible, however, to place a conservative value, based on cordwood values, on the trees killed through defoliation, and as this product is about the lowest valued yield of the forests, one can be confident that his loss figures will not be overestimates. The count of killed trees may be obtained in various ways. If the areas under consideration are not too large all dead trees may be counted, but in larger areas it will be more desirable to count representative plots from which total deaths may be figured. Whatever method is followed, sufficient dead trees should be calipered so that an accurate average diameter may be known. Having determined the total number of trees killed and the average diameter of these, it then becomes a simple matter to figure these trees in terms of cords by the aid of a yield table, compiled by Mattoon and Barrows.[2] Stumpage values for cordwood vary greatly, according to locality, and published data may be of little help. However, it is usually possible to get accurate information from owners of woodlots or dealers, and having obtained a unit value the total value of all trees killed may be computed by means of the following equation:

$$\frac{K \times A}{N} \times V = L$$

K is the total trees killed per acre, A the total acres affected, N the

[1]Some Results of the Defoliation of Trees. Jour. Econ. Ent., 18: 345–348. 1925.
[2]Measuring and Marketing Woodlot Products. U. S. Farmer's Bulletin 715: 18. 1916.

number of trees to yield one cord, V the stumpage value per cord, and L the total monetary loss.

In case it is possible to figure dead trees in terms of lumber, the number necessary to yield 1,000 board feet may be substituted for the number necessary to yield one cord of wood and the stumpage value for lumber may be substituted for the stumpage value of cordwood.

Objection may be raised to considering all such dead trees as total losses, for they may have fuelwood value if salvaged before deterioration, but it must be remembered that many of them would have an original value as lumber far in excess of fuelwood and the salvage value would not compensate for the lumber lost through their deaths

In order to determine the loss in growth through defoliation it is necessary to get accurate information on the percentage of the foliage eaten, and the acreage affected Once these figures have been obtained the determination of the loss becomes comparatively simple, as a given percentage of defoliation results in the same percentage decrease in growth.

Forests vary so greatly in composition, density of stands, and thriftness that there is wide difference in the amount of annual growth per acre. In general, however, according to Tillotson,[3] thrifty stands will grow, at the rate of 250 or more board feet of lumber per acre per year, and the value of standing timber may be set at $5 00 per thousand feet board measure. The value of annual growth per acre is therefore $1.25. Having established the value of the annual growth per acre, the amount of loss through defoliation is figured easily according to the following equation:

$$\frac{G \times D \times A}{1000} \times S = L$$

G is the average annual growth per acre, D the average defoliation per acre, A the acres affected, S the stumpage value of lumber, and L the total monetary loss.

Using this equation, if an acre is 50 per cent defoliated, the annual growth will be decreased in the same proportion and consequently the value of the annual growth will likewise be decreased in the same ratio, or by $.625, which represents the actual monetary loss through defoliation.

When trees are killed by defoliation in any plot for which it is desired to compute the loss, that suffered through decreased growth should, of

[3]The Care and Improvement of the Wood Lot, U. S. Farmers Bulletin 711: 16. 1916.

course, be figured only for the trees which remain alive. This may be done by first determining the original number of trees per acre, then subtracting the number of trees killed. By comparing the number of trees which remain alive with the number present originally, a proportion is obtained which will show the correct allowance to be made for killed trees. If part of the trees are dead it is evident that the possible annual growth per acre will be decreased in proportion.

The equations given in this paper may be used in estimating loss through defoliation by other insects in other sections of the country. It will of course be necessary to use values which apply to the particular types of products concerned and to the markets for which such products are intended.

MR. A. F BURGESS: The data refer more particularly to deciduous growth, but conifers undoubtedly lose a greater proportion of growth as they succumb more readily to defoliation. The formulae are based on June and July defoliation in New England August defoliation would be reflected possibly to a less extent in the growth for the following year

THE ORIENTAL MOTH (*CNIDOCAMPA FLAVESCENS* WALK.) IN MASSACHUSETTS AND THE WORK OF ITS NEWLY INTRODUCED PARASITE

By C W. COLLINS, *Senior Entomologist, U. S. Bureau of Entomology, Melrose Highlands, Mass.*

ABSTRACT

Paper calls attention to the establishment and distribution of the Oriental Moth (*Cnidocampa flavescens* Walk.) in Massachusetts, its favored food plants, seasonal history and means of artificial control. Especial attention is given to the introduction of a tachinid parasite (*Chaetexorista javanica* B. & B.) from Japan, its quick establishment and the rather high degree of control effected within three and four years after the first introduction.

Cocoons of the oriental moth (*Cnidocampa flavescens* Walk.) were first found on several kinds of fruit trees in the Dorchester section of Boston, Mass., in February, 1906 Previous to that time it was known to occur only in the Orient, namely, eastern Siberia, China, Chosen (Korea), and Japan. Since 1906 it has been a pest of fruit and shade trees in Boston and vicinity, its known distribution extending to Salem on the northeast, a distance of 14 miles, to Arlington and Watertown on the west, a distance of 6½ and 7 miles respectively, and to Quincy on the southeast, a distance of 8½ miles. Dispersion from the original

colony site has been slow, it having advanced only 14 miles to the northeast in 26 years or more.

Seasonal History and Food Plants. In the Boston area where this insect occurs it has only one generation annually. The adults appear over a period of about a month from the latter part of June to the latter part of July. They have a wing expanse of from 1¼ to 1½ inches and are light yellow on the thorax and inner portions of the wings, the other portions of the body and wings being light reddish brown excepting the fringes of the fore and hind wings, which are of a darker brown.

The eggs are oval, flattened, about one-sixteenth inch long, and are laid, usually singly, on the under side of the leaves. They hatch in about a week.

The larva, when it issues from the egg, is semitransparent. It molts once before beginning to feed, and five or six times more before becoming full-grown. With each succeeding molt it takes on a greater variety of color so that it presents a striking appearance with its markings of yellow, blue, green, and purple. The feeding by the young larvae is from the under side of the leaf and is accomplished by eating small patches of green tissue. As the larvae increase in size they consume the whole leaf, excepting the veins. The larva, when full-grown, attains a length of about seven-eighths inch. It then spins a very hard cocoon in the fork, or crotch, of limbs or twigs. This cocoon is elliptical and smooth and one side is attached to the bark. It resembles a bird's egg in appearance and is grayish-brown with white markings. The hibernation period is passed as a prepupa in the cocoon. Another molt takes place in the spring before transformation to the pupa.

The foliage of Norway maple, sycamore maple, buckthorn, black birch, wild and cultivated cherry, apple, pear, and plum has been found to be most commonly and severely injured by the larvae. When the insect is abundant, other less favored food plants, such as oak, other maples, poplar, willow, honey locust, hickory, and hackberry, are attacked. In Japan the oriental moth is said to be particularly abundant in certain pear-growing sections, and in other sections it is a common pest of persimmon and is sometimes numerous upon plum.

This insect continued to increase in the central part of its area of occurrence up to about 1930, since which time a decline in intensity of infestation has been observed. Counts of cocoons in nine observation points in the spring of 1931 and of the new cocoons in the fall of 1932 indicate that the infestation in 1933 will be only about one-fourth of that occurring in 1932. This reduction is due mainly to spraying and other hand methods of control and to the work of a few native incidental

natural enemies together with that of the parasite, *Chaetexorista javana* B. & B., recently introduced and established. The status of the parasite can best be illustrated from Table 1.

TABLE 1. LIBERATIONS OF A TACHINID FLY (*Chaetexorista javana* B. & B.), A PARASITE OF THE ORIENTAL MOTH (*Cnidocampa flavescens* WALK.), IN BOSTON, MASS., AND VICINITY, AND SUBSEQUENT PARASITISM BY IT

Points of liberation	Number of flies liberated		Percentage of parasitism[1]			
	1929	1930	1930	1931	1932	1933
1. Boston (Columbia Road)	2,221	——	1.3	7.0	——	40.5
2. Revere (Beachmont)	2,326	——	0.4	5.0	16.0	69.0
3. Boston (Jamaica Plain)	——	6,395	——	3.8	24.3	---
4. Boston (Boston St.)	——	5,848	——	1.0	18.5	58.0
5. Boston (Pope's Hill)	——	6,011	——	13.0	26.5	82.7
6. Boston (Neponset)	——	5,865	——	12.1	30.0	90.0
7. Chelsea	——	5,680	——	4.0	2.0	57.5
8. Cambridge	——	7,129	——	6.5	14.5	70.0
9. Quincy	——	5,854	——	7.4	27.0	66.6
10. Medford	——	7,076	——	17.0	10.5	48.0
11. Revere (Young's Hill)	——	5,146	——	7.3	10.0	25.5
12. Winthrop	——	5,063	——	3.7	27.0	62.7
13. Nahant	——	4,983	——	28.4	15.7	29.1
14. Everett	——	4,947	——	——	10.5	75.0
15. Saugus	——	6,171	——	——	42.1	100.0
16. Revere (Revere St.)	——	4,457	——	2.4	1.5	24.0
Total number of flies liberated	4,547	80,625				
Total number of cocoons collected for percentage of parasitism			764	1,901	2,498	2,235
Percentage of parasitism			0.78	8.57	16.49	52.43

[1]Based, in the majority of cases, on collections of 200 cocoons.

In this connection it is interesting to note that larval collections reared for 12 different years between 1916 and 1930 yielded only occasional native parasites (*Compsilura concinnata* Meig. and *Psychophagus omnivorus* Walk.) and these in small numbers. Collections in 1932 of eggs from eight points showed an average parasitization by *Trichogramma minutum* Riley of 5 per cent.

CONTROL. Field and laboratory experiments conducted in 1932 indicate that the larvae can be satisfactorily controlled by spraying with lead arsenate at the rate of 3 pounds to 100 gallons of water with the addition of fish oil or linseed oil, as an adhesive, at the rate of 4 ounces, or one-fourth pint, to each pound of poison used. This is sufficient to kill the larvae in the early instars, or from about August 1 to 15 in Boston, Mass., and vicinity. After the first of the larvae become about one-half grown, namely, August 15 or later, the dosage should be increased to 4 pounds to 100 gallons of water with the addition of fish oil or linseed oil in the same proportion as stated above.

If the trees to be sprayed are very close to houses or fences, where fish oil or linseed oil can not be used, 1 pound of lead arsenate should be

added to each of the above dosages. For best results the spraying should be done at least two weeks before the first larvae will become full-grown and begin spinning their cocoons.

If the cocoons appear in small numbers and on low growth, they can be crushed or hand-picked and destroyed.

THE STATUS OF THE EUROPEAN PINE SHOOT MOTH IN CONNECTICUT

By R. B. FRIEND and H. W. HICOCK, *Connecticut Agricultural Experiment Station, New Haven, Conn.*

ABSTRACT

The European pine shoot moth, *Rhyacionia buoliana* Schiff., has become a serious enemy of red pine in Connecticut, and its status in relation to forest plantings of this tree is discussed.

In 1915 Busck (U. S. D. A. Bull. 170) suggested that the European pine shoot moth, *Rhyacionia buoliana* Schiff., might become a serious pest of pines in America. At the present time it appears that this possibility is being realized in the red pine plantations in Connecticut. The insect was discovered in the state in 1914, but up to about 1926 it had confined its activities to nursery stock and had not been severely injurious to forest trees. During the last six years the injury to forest plantings, particularly those of red pine, has increased to such an extent that the insect is one of the most serious forest pests in the state, and unless its depredations are brought under control by natural or artificial means in the near future, many of our best red pine plantations may be rendered worthless.

The use of red pine as a species for forest planting in the state has increased rapidly during the last fifteen years. It is well adapted to natural conditions and had no serious insect or fungous enemies prior to the appearance of the shoot moth. Moreover, the white pine, a rather extensively planted species, is more or less seriously affected by the weevil and blister rust. There has been distributed by the State Forester of Connecticut and the Forester of the Connecticut Agricultural Experiment Station a total of approximately 10,500,000 red pine trees for planting on public and private lands in the state. Assuming an average rate of planting of 1,200 trees per acre, this would make about 9,000 acres of red pine, and to this must be added several hundred acres planted with trees obtained from private sources. The area planted by any one individual or group of individuals varies from a fraction of an acre, in the case of some farmers or owners of estates, to several hundred

acres, in the case of some public utility corporations for the protection of watersheds. Natural red pine is rare in Connecticut and of no economic importance.

Most of the sites planted to red pine are of rather good quality, in many cases being old agricultural land, and where not badly affected by the shoot moth the trees are growing well as a rule. Usually red pine is planted in the open in pure stands, and the area of any single block of trees is not in most cases very extensive. Uninterrupted stands of over 25 acres in extent would be comparatively rare.

During the last two years an examination of the red pine plantations of the state has been undertaken with a view to determining how badly they are infested by this shoot moth. This examination has not been completed yet, but 149 infested plantations have been found, and the aggregate area of these is approximately 3,000 acres. About one-fifth of this total area is heavily infested, and the remainder lightly infested If the watersheds owned by two public utility corporations in New Haven and Fairfield Counties were excluded, the proportion of the area that is heavily infested would be considerably less in the other portions of the state.

As has been mentioned above, the European pine shoot moth was not known as a forest pest in Connecticut until about 1926, that is, twelve years after its discovery in the state. Even as late as 1926 the serious injury in forest plantations was confined to one block of red pines in Fairfield County. During the last six years, however, many other areas in Fairfield and New Haven Counties have become infested to a more or less serious extent, and since 1930 the spread of the insect has become increasingly rapid. The year of the introduction of the insect into a plantation may usually be fairly accurately obtained by determining the year in which the oldest apparent injury to the trees occurred. Due to the fact that the infestation of a plantation is almost without exception very light the first year and the injury caused at this time may be very easily overlooked, in many cases the date determined may be a year late. With this qualification the following figures give a general idea of the rate at which the insect has dispersed throughout the state. Records of 92 plantations about which we have reliable data show that two were infested before 1927, five more became infested during each of the years 1927, 1928, 1929, 10 more became infested in 1930, 43 more in 1931, and 22 new infestations were added in 1932. The number of plantations examined since the flight season of 1932 has been much less than the number examined between the flight seasons of 1931 and 1932, so the fact that only 22 new infestations were added in the latter year

does not necessarily mean that the dispersion of the insect has not been as rapid during the last season as during that preceding. It seems probable that we are at the beginning of an outbreak of the insect which may assume serious proportions.

We consider that the two most important agencies which operate to disperse the insect throughout the state are (1) adult flight aided by wind and (2) the transportation of larvae in trees used for ornamental planting. From what we have seen of the activities of the adult it appears that the insect does not tend to fly far, but hovers about the vicinity of the trees in a rather restricted locality. This habit and the fact that the adult flies at night when the wind velocity is normally low may account for the relatively slow spread of the insect throughout the state. Nevertheless the conditions surrounding some of our infested plantations indicate that adult flight aided by wind was the means by which the insect arrived. The initial infestations of plantations have been, in our experience, almost without exception small, a condition that would be expected in view of what has been said about adult flight.

The situation as regards spread by ornamental plantings is none too optimistic. Among the host plants of this insect are many trees used for this purpose, and on some of these trees the infestation may persist for several years before it is noticed by the owner During the last year (1932) the shoot moth was found in 77 nurseries in the state, as against 31 in 1931 and 17 in 1930. The infestations in nurseries are presumably cleaned up each year before the stock is shipped, but they constitute a potential source of dispersion nevertheless.

At the present time the insect is most abundant in the southwestern part of the state; that is, in New Haven, Fairfield, and the southern part of Litchfield Counties. Heavily infested plantations in particular are more abundant here than elsewhere. Of the infested plantations recorded to date, about 70 per cent are in these three counties, and all but two of those heavily infested are here. In regard to nurseries, whereas these three counties contained 60 per cent of the 327 registered in 1932, they contained 80 per cent of those found infested the same year. The eastern half of the state has not been as thoroughly examined as yet, but in all cases found affected by the shoot moth to date, the infestation has been light. Red pine plantations are not so numerous here as they are further west. The direction of spread in the state is from southwest to northeast, and in time the insect will probably be more abundant in sections where it is now rare.

The dispersion of the insect throughout a plantation in which it has become established, both laterally and vertically, is of some interest.

Some of the red pine blocks many acres in extent show seriously damaged trees in one corner or one end and a gradual decrease in injury away from that focus. It appears that the insect population tends to build up around the point of original infestation without a correspondingly rapid lateral dispersion. The adults tend to oviposit in the tops of the trees, with the result that there is a decrease in the per cent of injured tips from the top of the tree toward the base.

In regard to the effect of the insect on the tree itself, only three species of host plants are at present important in forest plantings in the state and will be mentioned here; that is, the white, red and Scotch pines. The white pine has not been affected to any economic extent as yet, and we have observed nothing to indicate that it will become seriously injured in the near future. Even where interplanted with heavily infested red pine, the white has not been injured Scotch pine is a native European host plant of the insect, but it does not appear to be injured as severely as red even when infested for the same or a greater length of time. This should not be taken to mean that Scotch pine will not be severely damaged, for some of our forest plantings of this species are certainly in bad shape at the present time. At present the red pine plantations, which are more numerous than the Scotch and are generally more promising except for the depredations of this insect, are our chief concern, and efforts to control the pest are directed against it chiefly as an enemy of this tree.

Under normal conditions a heavy infestation develops in a red pine stand after the insect has been present about three years The larval attack causes deformation, stunting, and the death of the tips, both terminal and lateral. In only two instances have we observed a failure of the infestation to increase in intensity after the insect became established in a red pine plantation. Where a mixed planting occurs or the red pines are overtopped by hardwood sprouts, such conditions do not appear to offer much protection unless the cover is so dense that the pines are severely suppressed. The quality of site, as reflected in the rate of growth, affects the degree of injury caused by this insect only in that, as would be expected, trees on a poor site appear to succumb somewhat more rapidly than those on a good site. A good site, however, does not seem to afford the trees an opportunity to overcome the injury as long as the insect is present.

European entomologists consider this insect to be primarily a pest of young trees. The age of the oldest red pine plantation in the state is 33 years, so whether or not this tree will be relatively free of injury after it has attained a fair height has not been determined. We have had

severe outbreaks in plantings where the trees were from 2 to 25 feet in height, although in the latter cases the initial infestation occurred when the trees were several years younger.

During the last season eight species of insect parasites have been reared from shoot moth material collected in Connecticut. Six of these are known as larval parasites of the Nantucket pine moth (*Rhyacionia frustrana* Comstock). Of the other two, one is an egg parasite, a species of Trichogramma, and the other is a larval parasite of undetermined species. The effect of these native enemies of the shoot moth in depressing its potential increase cannot be determined without further work

DR. SWAIN. Is there any effective method of control by spraying? We are trying that method ourselves. We haven't succeeded very satisfactorily yet.

A second question is—to what extent are commercial nurseries a danger in spreading the infestation?

DR. FRIEND: To answer the first question first, our field experiments have been rather limited, but in the laboratory we have found that a little summer oil with a concentration of about 2 per cent of the commercial oil, plus lead arsenate at the rate of three pounds to one hundred gallons gives a very satisfactory control. The eggs are killed by the oil, and the lead arsenate will prevent larvae from entering the twigs.

We find in our investigations of feeding habits that the larvae tend to bore into the base of more than one shoot. For example, on one small test of five larvae on one shoot, we find about eleven needles bored at the base. We found that, in duplication of that experiment, to be the same.

In regard to commercial nurseries, I think in Connecticut where we have estates which have ornamental plantings and at the same time forest plantings away from the house, that a shipment of ornamental trees is a distinct menace. In particular, I think mugho pine is dangerous because it is a shrub and something the owners do not expect to grow to any great height. The infestation stays on mugho pine for a considerable time before any injury is noticed.

Certainly the present indications are that ornamental plantings have been important. The large percentage of infested nurseries are in the southwestern part of the state and there are infested plantations at the same time. The insect was found in the nursery before it was found in any plantation. We have reared eight species of native parasites during the past season, of the shoot moth in Connecticut. The parasites are native. The shoot moth is exotic.

All except one species have been recorded on the Nantucket pine shoot moth by Cushman, and that we haven't had determined definitely yet.

In one small group of trees we found about 50 per cent of the larvae in May parasitized by the different species together.

Dr. Felt: Supplementing the remarks by Dr. Friend, we have obtained a very satisfactory degree of commercial control for this moth in spraying with a light oil, nicotine and arsenate of lead at the time the moths are beginning to fly and about two weeks later as outlined by Dr. Friend in plantations of considerable size under outdoor conditions.

SOME EXAMPLES OF VARIETAL RESISTANCE OF PLANTS TO INSECT ATTACKS

By G. F. MacLeod, *Ithaca, N. Y.*

Abstract

Sweet spanish varieties of onions proved resistant to onion thrips (*Thrips tabaci*) and green celery varieties resistant to injury by tarnished plant bug (*Lygus pratensis*)

Entomologists engaged in studies of insect control have frequently been accused of being "insecticide-minded." Certainly in the training of younger entomologists the subject of insecticides has been most strongly dwelt upon. Without any intent to minimize the important and numerous successes in which insecticides feature, some question may be raised as to the lack of attention given other methods of attacking problems of insect control. The comparatively recent stimulation of investigations in biological control have certainly assisted in broadening both viewpoint and the actual field of entomological endeavor. For some unknown reason the varietal resistance of plants has claimed the attention of only a few entomologists. A few instances of the practical value of plant resistance to insect attacks are on record but little is known of the fundamental reasons involved. Many cases of resistance or susceptibility are common knowledge with entomologists but unfortunately relatively little data appears in the literature. It is the purpose of these notes to present some evidence regarding the susceptibility of plant varieties to insect attacks.

In a series of investigations dealing with the control of onion thrips and tarnished plant bug in New York State there arose opportunities to study plant resistance to attacks by these insects. The only method of procedure available was most simple. Rod-row plats of all varieties

obtainable were planted side by side with several replications. The experiments with onions were carried on in Orange County, New York by F. B. Maughan, while the celery tests were conducted by L. L. Hill on farms near Williamson, Wayne County.

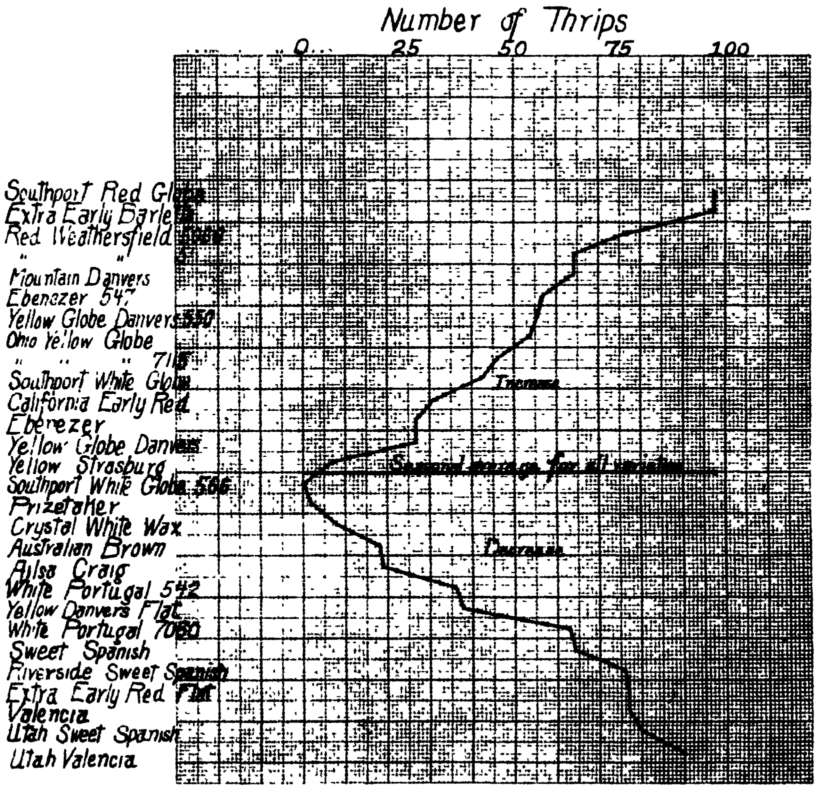


FIG. 1.—Increase or decrease in comparative numbers of thrips on each onion variety over or under the average of all varieties.

STUDIES OF THE POPULATIONS OF THRIPS ON ONION VARIETIES. Counts of the numbers of thrips on 20 onion plants in each variety plat were made at intervals of about two weeks during the period of infestation. Five such counts were made throughout the season. A total of 13,651 thrips on 2800 plants were counted to give the results expressed in Figures 1 and 2.

In Figure 1 all varieties tested are listed in receding order of resistance from top to bottom. Those varieties above the line of the general seasonal average for all varieties may be considered as sus-

ceptible while those below show resistance. The varieties may be classified as follows:

SUSCEPTIBLES	AVERAGE	RESISTANTS
Southport Red Globe	Crystal White Wax	Utah Valencia
Extra Early Barletta	Yellow Strasburg	Utah White Sweet Spanish
Red Wethersfield	Prizetaker	Valencia
Mountain Danvers	Southport White Globe	Extra Early Red Flat
Ebenezer		Riverside Sweet Spanish
Yellow Globe Danvers		Sweet Spanish
		White Portugal
		Yellow Danvers Flat

Using the above classification Figure 2 was prepared. The differences between each group are consistent and distinct. Moreover vari-

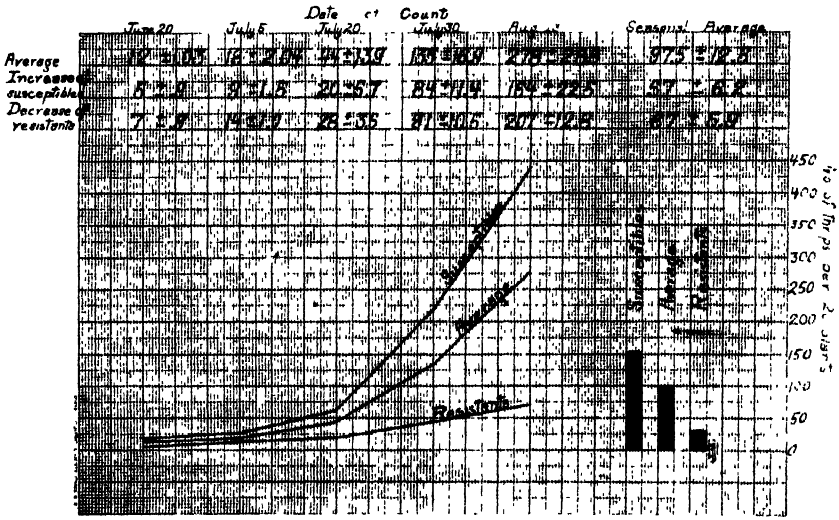


FIG. 2.—Differences in infestations of thrips on susceptible and resistant onion varieties compared with the average for all varieties.

ations in resistance become more marked with the seasonal increase in numbers of thrips. The domestic varieties or those most susceptible to thrip injury are the types commonly grown on a commercial scale in the region where these tests were conducted. The resistant forms are of the sweet spanish type. As might be expected the average varieties are an admixture of these two types.

VARIETAL RESISTANCE OF CELERY TO TARNISHED PLANT BUG INJURY. In the varietal tests for resistance to tarnished plant bug injury the appearance of celery blight in experiments two and three (Figure 3) required the application of bordeaux mixture. This treatment un-

questionably reduced the total amount of plant bug injury but since all plats were treated alike the varieties are comparable insofar as resistance to injury is concerned. A total of 14,632 individual celery plants

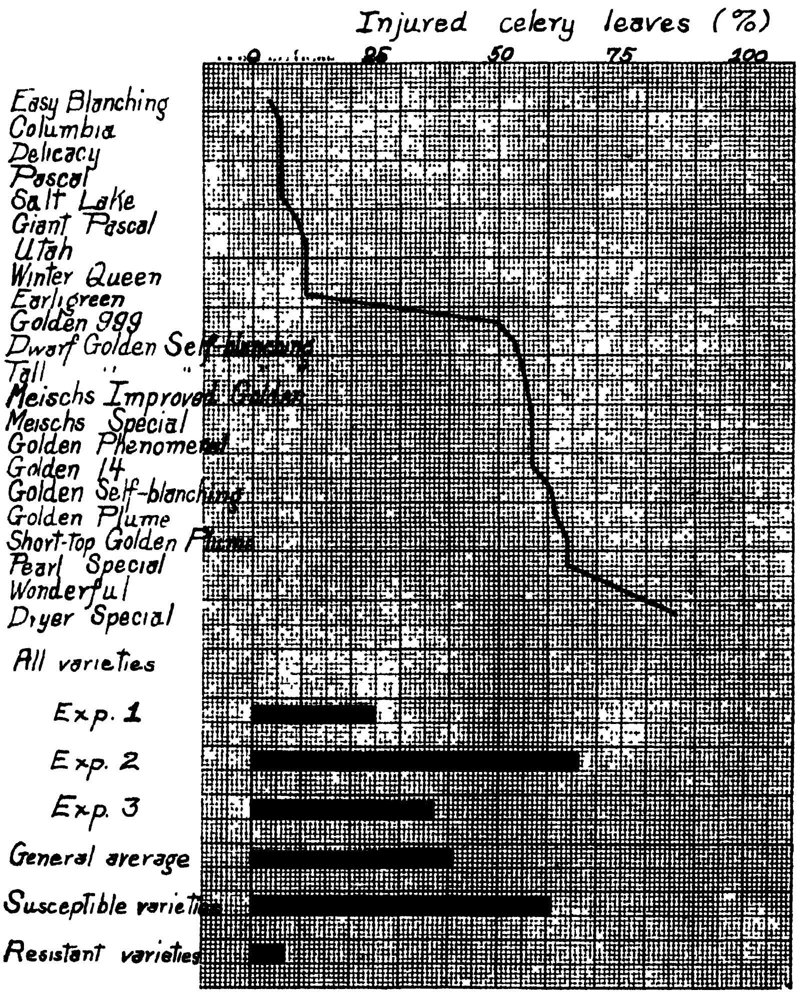


FIG. 3.—Resistance of celery varieties to tarnished plant bug injury.

were examined and the injury to leaves recorded as "slight," "moderate" or "severe." The injuries recorded as slight would affect the plants but little as stock for immediate consumption but celery thus injured would probably not keep well in storage. Plants suffering either moderate or severe leaf injury were distinctly second grade and unfit for use.

The proportion of injured leaves on all varieties tested in all experiments is shown in Figure 3. It is very apparent from this work that green or semi-green varieties are extremely resistant to plant bug attacks. There is a more clear cut line of differentiation between resistant and susceptible celery varieties than is the case with onions.

As to the severity of injury within each grouping of celery varieties Table 1 shows clearly the preponderance of severe injury with susceptible varieties and the larger proportion of slight injury to resistant strains.

The reasons for this selective resistance of celery and onions to the most common insects associated with large plantings of these vegetables are unknown. The fact that marked differences do exist, that these differences are in some way associated with greenness of celery and some unknown characteristic of sweet spanish onions, affords the basis for future work of both practical and scientific value.

TABLE 1. THE RELATIVE AMOUNTS OF TARNISHED PLANT BUG INJURY TO CELERY VARIETIES

	Degree of injury		
Classification	Slight per cent	Moderate per cent	Severe per cent
Resistant varieties.....	$4\pm.9$[1]	$2\pm.8$	$.5\pm1.4$
Average—all varieties...	17 ± 2	17 ± 4	8 ± 2
Susceptible varieties.. ..	23 ± 2	25 ± 2	14 ± 3

[1]The error given is the standard error in all cases.

DR. FRIEND: I particularly am interested in this because of the work we have recently done with the spruce gall aphis. As a nursery pest, this spruce gall aphis has attracted considerable attention in recent years, and as a forest pest in some of the spruce plantations in the watershed around New Haven it also attracted a great deal of attention. We found, when we made a thorough investigation of the plantation, that about 30 per cent of the trees were absolutely immune even though there were branches close to the infested trees.

These trees have been exposed to the spruce gall aphis at least 12 years because we could trace it back 12 years over the infested trees. Another 30 per cent were so slightly affected that the insects had no effect on the growth of the tree, whatsoever. So we have two-thirds of the trees on a plantation infested by the spruce gall aphis for a period of 12 to 15 years with no visible injury present.

As a result, we concluded as a forest pest the spruce gall aphis is not of any great economic importance. In spite of the fact, you occasionally meet with a tree very severely injured by the pest. We do not know the reason for the immunity. The winged generation of the aphis flies to the immune trees, deposits eggs and the nymphs which hatch attack the

buds. However, during the winter and early spring before the oviposition period arrives, all the buds die on the immune trees.

Dr. Painter: At Kansas State Agricultural College we have a cooperative project between the Agronomy Department and the Entomology Department on this particular subject. We have tried to get together a good many of the references, as many as we can, dealing with subjects related to insect resistance. I recently made a count of the entries in our bibliography and they amounted to something like 250 references.

It seems to me in addition to the importance as a possible control measure, insect resistance offers an aid toward reducing the hazards incident in farming.

NOTES ON THE GIANT TOAD, *BUFO MARINUS* (L.), IN PUERTO RICO

By M. D Leonard, formerly *Entomologist, Insular Experiment Station, Rio Piedras, P R.*[1]

Abstract

The distribution, life-history, and habits are given so far as known; a detailed study of the food-habits in Puerto Rico is summarized, indicating the large quantities of injurious insects consumed; the shipment of live toads to Hawaii and their initial successful establishment there is noted.

The giant toad, *Bufo marinus* (L.) has been artificially introduced into several of the West Indian Islands and more recently into the Hawaiian Islands for the control of certain injurious insects. Its rapidity of spread and increase in numbers, its great capacity for devouring injurious insects such as June beetles, weevils and the like, and the ease with which it can be transported for great distances alive, prove it to be an insect predator of considerable value. Since comparatively little has been published on this toad, especially in reference to its food-habits, it is felt that a brief summary of what is known about it, especially concerning its activities in Puerto Rico, will be of interest to entomologists in many parts of the world.

Distribution. *Bufo marinus* is known to occur from the Lower Rio

[1]Thanks are due to Drs. A. H. Wright and S. C. Bishop of the Departments of Zoology of Cornell University and of the University of Rochester respectively for assistance in locating the literature on *Bufo marinus*. One of the best and most recent accounts is by Remington Kellogg on "Mexican Tailless Amphibians in the United States National Museum." In U. S. N. M. Bul. 160: 53–57. 1932.

Grande Valley in Texas thru Southern Mexico and Central America to Southern Peru and Northern Argentine and has been said to range as far southward as the Patagonian district. It also occurs in Trinidad and Tobago and is either indigenous to or has become established in many of the West Indian Islands, especially those of the Lesser Antilles. It has also been introduced into Bermuda and is said to have been taken to Jamaica from Barbados as early as 1844. This toad has apparently been able to adapt itself to considerable extremes of temperature since it thrives in the warm climate of sea level in the West Indies and has been taken in Southern Peru from July to December as high as 6000 ft.

Description and Life-History. This is the largest of the true toads, specimens having been reported (from Brazil) measuring as much as 9 inches from snout to vent. The female apparently attains a greater size than the male. The color is variable but is usually composed of shades of brown including yellowish, reddish or even blackish; the upper parts are with or without large blackish insuliform spots and a lighter vertebral line is sometimes present, the arms and legs are a dingy white or yellow. Sexually mature males have numerous low spiny tubercles on the back; the male is often lighter in color than the female.

The life-history of this great toad seems to have been but little studied but it presents interesting features judging from what is so far known. In Puerto Rico, at least, breeding seems to be continuous the year around since eggs have been collected in nearly every month. In certain other places breeding seems to be confined to the rainy season, mostly during three or four months. According to Mrs. Dexter's observations in Puerto Rico the small pale yellow eggs are embedded in large numbers in a mass of foam which looks like the white of a beaten egg. These masses are commonly observed at or near the edge of pools or ponds. Mark (see Pope, P. H. in Bul. Mus. Comp. Zool. 61 (6): 123 124, 1917) observed eggs in Bermuda which hatched in a few hours less than four days. Dexter states that after 24 to 48 hours the embryos pass into the water where they show great activity, constantly coming to the surface to nibble at the foam which serves as their first food. When this is gone food is procured from the slime in the water until the young toads are ready to take to the land. It has been stated that they leave the water when they are no more than ¼ inch in length. It is not known just how long the tadpole stage lasts but apparently transformation to the toad is rapid. Ruthven states that in Demerara it takes 45 days from egg to adult. It is quite probable that this toad may require but a very small amount of water to successfully pass thru its early stages. Dr. Danforth of the College of Agriculture at Mayagüez has several times made this

statement to the writer and has reported (Copeia, 1925, p. 76) that one observer had seen eggs laid in crannies in the side of a well.

INTRODUCTION INTO PUERTO RICO. *Bufo marinus* was first introduced into Puerto Rico from Barbados in 1920 by the Federal Agricultural Experiment Station at Mayaguez. The purpose was to reduce the numbers of several major insect pests such as "June beetles, mole crickets and cockroaches." The toads were freed in the vicinity of Mayaguez and as they increased in numbers were sent to various parts of the Island in lots of 2 to 2000, a single shipment to the Aguirre Sugar Co. consisting of 1114 individuals for the control of white grubs in their plantations. In 1924 the Insular Experiment Station at Rio Piedras imported 40 specimens from Jamaica for distribution in the Island. The species is now well established in most parts of Puerto Rico and has proved a valuable introduction from the standpoint of insect control. It is probably more abundant in the vicinity of fresh water ponds but is often found a considerable distance from water. It is for the most part nocturnal in its feeding habits, remaining hidden during the day under stones, in holes or under clods of earth During rains the toads often become active in considerable numbers in the daytime Many are killed by automobiles on the highways by night.

FOOD-HABITS. Until recently but few definite observations had been made on the food-habits of this toad, altho it was known of course to eat insects, some of which were injurious. May (Agricultural Notes No. 26, P. R Agr. Exp Sta , Apr. 1926) states that in 3 months one toad will eat nearly 10,000 injurious insects which constitute 88% of its food. In the Rept. P. R. Agr. Exp Sta. for 1929, p 4 he says that stomach examinations showed remains of changas, white grubs, ants, cockroaches, etc. Seín of the Insular Experiment Station had also made some analyses of the excrement for insect remains. Noble (Bul. Am. Mus. Nat. Hist. 38: 333, 1918) states that in Nicaragua the few stomachs he examined contained a varied diet but mostly cockroaches, due to the toads having been collected around street lamps. Taylor and Wright (Univ. Kans. Sci. Bul. 20 (12): 247-249, 1932) examined the stomach contents of several specimens in Texas and found the remains of large Tenebrionid and Carabid beetles, the bulk of which were Eleodes and Pasimachus; other insect remains were unidentifiable.

In order to more accurately determine the food-habits of the giant toad in Puerto Rico, at the writer's suggestion, Mrs. Raquel R. Dexter[2]

[2]Her paper was preprinted as Bulletin No. 74 of the Int. Soc. Sugar Cane Technologists, 4th Congress, San Juan, P. R., to appear in the Proceedings of the Congress early in 1933.

of the Department of Biology of the University of Puerto Rico commenced a detailed study in the early fall of 1931 and continued it until the winter of the following year. Detailed observations were confined almost entirely however to the sugar growing sections, later studies to take in the other important crops. A total of 301 toads were taken in 18 localities thruout the sugar growing belt. The specimens were all collected between 5.00 and 9.00 a. m. and the stomach and intestine at once removed and preserved for careful qualitative and quantitative analyses of the contents. By bulk 51% constituted insects injurious to agriculture, 42% neutral species, and 7% beneficial species. The injurious forms were largely Phyllophaga and Diaprepes but included also several other more or less injurious weevils and the changa or West Indian mole cricket. The beneficial forms referred to were the wasp, *Campsomeris dorsata* (70 specimens), a known parasite of white grubs. These however were found in 8 toads taken at the same time in one restricted place. None of these toads had eaten Phyllophaga since there were no food-plants there to attract the June beetles It is believed that the eating of these parasitic wasps was unusual. Six orders of insects were included in the food of the 301 toads examined. In addition millipedes constituted 26% of the total food by bulk and a few snails, slugs, spiders and phalangids had also been eaten

It is the opinion of the leading sugar cane specialists and Central managers in Puerto Rico that the giant toad has been an important factor in reducing the white grub problem A detailed study of the food of this toad would indicate that this is undoubtedly the case. Where plants such as bananas are grown which attract the June beetles it was found that the toads are capable of eating 12.5 beetles per night. To show what the toad can do under favorable conditions an example is given by Mrs. Dexter in her paper. In 1913–1914 one Central spent $1876.73 for the hand-collection of 1,662,000 beetles over a period of 133 days. At the rate of 12.5 beetles per night 1000 toads could eat the same number of beetles in the same length of time and at no cost at all.

INTRODUCTION INTO HAWAII. Mr C. E. Pemberton, Entomologist of the Hawaiian Sugar Planters' Experiment Station, when attending the Fourth Congress of the International Society of Sugar Cane Technologists held in Puerto Rico in March 1932, became greatly interested in *Bufo marinus*. After carefully studying the available data as to food-habits and personally observing the toad in various parts of the Island he decided to attempt an introduction into Hawaii. With the assistance of Mr. F. Seín Jr. of the Insular Experiment Station and the writer four shipments were made at weekly intervals from

March into April. The first three were sent by express from San Juan to Honolulu, going via boat to New York, by train to San Francisco, thence by boat to Honolulu. They averaged 3 weeks in transit. The fourth was taken personally by Mr. Pemberton by air-plane to Miami and by train to Los Angeles where he put the box on a boat for Honolulu. This was only 13 days on the road. A total of 149 toads shipped, all arrived alive and in good condition. They ate heartily upon being offered various kinds of insects upon being unpacked. Each lot had been put in a strong wooden box in which a few small holes had been bored and a narrow strip left open at the top. The box was filled with excelsior, well moistened with water, into which the toads burrowed. No food was included. The method of packing was suggested to us by Major Chapman Grant, the well-known authority on Puerto Rican amphibians and reptiles. Check toads were kept under similar conditions at the Experiment Station for over 2 months at the end of which time they were perfectly healthy altho somewhat shrunken in size from lack of food and water. This showed that it should be possible to ship these toads alive for very considerable distances.

Under date of October 29, 1932, Mr. Pemberton wrote me that the toads were doing well in Honolulu. They had been divided into two lots and released at two reservoirs near the city about 3 or 4 miles apart. He says "There are now many young toads about 1½ inches long in one section where 80 of the toads were liberated. It will probably be a year or more before they will be conspicuous. Yesterday I found a pair of the original adults backed down in a hole in a cane field at least half a mile from where they were liberated. Several can still be found in the pond where they were put out. . . . Certainly they are established for we have been able to find young ones now for just two months and young of two sizes indicating two separate periods of deposition of eggs which had been fertilized."

DR. SWAIN: I should like to ask Dr. Leonard if he knows how much cold these toads will stand.

DR. LEONARD: I cannot tell that. That is one of the things which we would like to know very much. They have been found as high as 6000 feet in Southern Peru by Dr. Noble several years ago when he was on an expedition from the American Museum of Natural History. I presume the temperatures would run fairly cool.

Last winter or early spring I had some correspondence with Dr. Hinds while I was still in Puerto Rico in regard to the possibility of attempting to introduce this toad into the sugar cane fields of Louisiana. The point

came up as to whether we thought they could withstand such winter temperatures as they would encounter there.

Apparently, I should judge, they can withstand a considerable temperature range. How low they will go and still survive and breed, I would not know. That, of course, would be one of the practical considerations for possible introduction in certain places.

JUSTIFYING EXPENDITURES FOR ENTOMOLOGICAL RESEARCH

By J. J. DAVIS, *Purdue University*[1]

ABSTRACT

A summary of facts which justify federal and state expenditures for entomological research, with special reference to the many indirect benefits to Agriculture, other than the control of insects, which have resulted from studies on insects and insect control.

Insects and insect problems date from the very beginning of agriculture. Insect control, as a science, known as economic or applied entomology, dates back perhaps not more than 60 years. The statement has been made that man has been driven from tropical countries because insects gained the upper hand. Further statements have indicated that insects are encroaching on man's domain in the temperate regions and that unless greater efforts are made insects will overrun the earth. True, with the increase in cosmopolitan trade and especially with the increasing ease of communication between distant countries, the insect problems resulting from the introduction of insects from one country to another becomes an increasingly serious menace. On the other hand, if we look over the accomplishments of entomological research during the past 60 years, a comparatively short space of time, we cannot but marvel at the results obtained in the development of insect controls and preventives. Certainly if we discontinue insect studies which have been so well begun we may anticipate insect su-

[1]The writer of this compilation of facts is greatly indebted to the following entomologists for the information given: F. C. Bishopp, A. F. Burgess, L. Caesar, D. J. Caffrey, F. C. Craighead, G. A. Dean, C. J. Drake, W. P. Flint, W. E. Hinds, J. S. Houser, Roy Hutson, J. A. Hyslop, W. H. Larrimer, Geo. A. Maloney, Dudley, Moulton, Wilmon Newell, W. C. O'Kane, T. H. Parks, P. J. Parrott, A. G. Ruggles, Franklin Sherman, Jr., A. L. Strand, Claude Wakeland, J. R. Watson, R. L. Webster and C. A. Weigel.

This is a contribution from the Department of Entomology, Purdue University Agricultural Experiment Station.

premacy. New problems, as well as some of the old problems, require continued and even greater efforts on the part of the investigator, but the results of the past 60 years thoroughly demonstrate the ability of scientific workers to discover means of control if given the opportunity.

In presenting this thesis I have two major ideas in mind. First, the direct protection which the human race has received from the studies of insects during the past half century, and second, the indirect benefits of entomological research to agriculture and the industries, which are usually disregarded or unknown but which in themselves are many times more valuable than the costs of the studies, regardless of the insect control involved.

The statement has been made that the United States is suffering from over-production and, therefore, any effort to control the insects, which reduce crop yields, is undesirable. Such reasoning is obviously incorrect because in most cases the loss results after a greater part of the cost of production has been made and insect control in most cases reduces the cost of production. This is true even in years when the value of the crop is low. To cite a specific example: In our Indiana potato spraying experiments in 1931 and 1932, when the value of potatoes was 50c a bushel for number 1's and 25c for number 2's, the increase in value of sprayed potatoes amounted to $34.00 in 1931, and $30.00 per acre in 1932, after all expenses of spraying were deducted. Certainly it would be far more profitable to stop the growing of crops on marginal land poorly adapted for farming and from which a living can seldom be derived, than to discontinue insect control.

At the present time losses from insects amount to $2,000,000,000 annually. What might be the loss if no controls had been developed and applied during the past half century. When we stop to think of the innumerable insects which may destroy our various crops, attack our animals or our own persons, or which may destroy our clothing or homes and then understand that controls for 75 per cent of these destructive insects have been developed during the past 60 years of the science of entomology, we at once must admit that no further justification for entomological research is necessary.[2] And yet we could justify the expenditure for entomological research on the by-products alone. And so I wish to briefly point out some of the indirect benefits to the human race, and especially to farmers, from entomological research.

In the beginning it is conceded that many of the so-called farm prac-

[2]On account of space the writer has omitted a review of the important direct benefits resulting from insect studies and has included only representative examples of indirect benefits.

tices recognized as valuable in insect control, such as good seed bed, good seed, adequate fertilization, time of planting, proper cultivation, good drainage, clean culture, crop rotation and time of harvest, were recognized as good agronomic practices before they were recognized as of value in insect control. And yet, the fact that entomological studies have shown them to be effective in insect control has increased the incentive for their adoption so that in many cases, were it not for the insects, these good agronomic practices would not be generally used.

Tremendous acreages of valuable agricultural lands have been made available for cultivation as a result of drainage. It is true that much of this drainage was done primarily to reclaim the land for agricultural use but on the other hand much of it was done to control insects such as wireworms and mosquitoes. For example, the drainage of the Hackensack meadows for the control of mosquitoes as pests of man, resulted in greatly improving the value of these meadows and surrounding areas for the production of hay, successful livestock and poultry industries and for manufacturing industries. Numerous examples, such as the one cited, could be given.

European corn borer investigations have shown a number of incidental results, perhaps the most outstanding being those resulting from corn variety studies. The studies have first of all given an impetus to corn breeding and already some of the strains and hybrids developed as tolerant or resistant to the corn borer, also show a resistance to other insects and diseases and an ability to stand up under stress of adverse weather conditions. Corn borer research has given considerable impetus to agronomic investigations in the manner of applying fertilizers to corn, especially through the studies relative to the proper placing of the fertilizer with respect to the hill. Corn borer studies have also resulted in the development and adoption of plows and attachments thereto for the clean coverage of corn stalks, straw, manure and heavy cover crops. These new plowing devices will undoubtedly show increasing value in improving conditions of the soil and of agriculture in general, and will prove especially useful in areas where much crop refuse needs to be turned under. Furthermore, deep and clean coverage of corn residues as recommended for corn borer control, lowers the prevalence of wheat scab (*Fusarium moniliforme*). Similarly these practices have led to a marked reduction in weeds. The studies have stimulated and hastened the development of low-cutting corn binders and stalk shavers, which have been adopted in field work against the pink boll worm of cotton and the larger corn stalk borer. Aside from improving conditions in the corn fields for crops following, especially wheat, the additional fodder secured

by the low-cutting operation is a distinct advantage in sections where tonnage of fodder produced is important. The development of clean raking implements as a result of corn borer investigations has proven useful in clean-up control for the pink bollworm of cotton and, furthermore, they have proven highly desirable to recover larger quantities of commercial hay when used in ordinary farm operations. The discovery that husker-shredders kill 100 per cent of the corn borers in infested corn stalks has stimulated the use of these machines and it is universally agreed that the husker-shredder method of handling corn constitutes an improved agricultural practice, owing to the complete use of the shredded or finely cut plants for fodder and bedding; also, its easy incorporation and disintegration in the soil.

The several ways in which corn borer research has benefited agriculture have been enumerated to illustrate the many ways in which such studies relate to agriculture. Most of our major entomological research problems yield results which in addition to the development of a control for the insect pest, have a beneficial effect on agriculture many times the cost of the investigations.

In orcharding we find numerous practices developed for insect control which are valuable in other ways. For example, the simple recommendation of burning dead trees and prunings to aid in shot hole borer control is likewise effective in preventing the spread of some fungus diseases. Picking plum and peach drops, recommended in the control of the plum curculio, destroys much brown rot and other fruit diseases. Control of the apple flea weevil by cultivation of sod orchards has resulted in improved conditions and general rejuvenation of old trees. The discovery that water sprouts on apple trees stimulates outbreaks of aphids has resulted in recommendations for the general practice of removing such water sprouts early in the summer and this practice not only aids in aphis control but improves the condition of the trees and considerably lowers pruning costs the following year. Sanitary methods of insect control in orchards has yielded indications of worthwhile results in the control of some fruit diseases. And finally fruit insect and disease investigations have been the forerunners in the development of grading orchard products.

The discovery of lime-sulphur as a control for the San Jose scale gave the clue to the control of peach leaf curl. This in turn led to experiments with lime-sulphur against other orchard diseases and now we find this insecticide is the best fungicide for a number of plant diseases.

In reviewing the progress in vegetable crop insect investigations we find many indirect benefits. The Bordeaux-lead sprays recommended

for the control of insects and diseases of the potato plant prove to be stimulating to the plant.

Early planting of cucumbers has been advocated as a precaution against the melon worm and pickle worm in Florida. This has resulted in increased income because they now find that these early planted cucumbers always bring a better price.

The bean maggot or corn seed maggot as it attacks beans, has been a serious menace to the bean crop of the country, especially in Michigan where the average value of this crop is $18,000,000. Formerly the loss from poor stands, largely the result of bean maggot attacks, was, on an average, 35 per cent of the crop. The practices recommended for bean maggot control, which included shallow planting and compacted soil, have had an important effect upon the maggot but growers now believe that these "maggot-control practices" have an equal value in enabling the plant to rapidly establish itself.

It has been commonly stated that the cotton boll weevil has been a Godsend to the southern states because it has made necessary the rotation of crops. By adopting boll weevil control recommendations, including rotation, production has increased from 1/3 bale per acre to two bales per acre, reducing costs of production from more than 20 cents per pound to 5 to 9 cents per pound. As Dr. W. E. Hinds has stated, "the benefits resulting from the fight against the boll weevil are too numerous to be fully enumerated, but among them we must consider that it is now easily possible to produce cotton at a greater profit than before the weevil occurred. The standards of living and of health on the farms have been greatly improved. Both the agricultural and economic systems of the Cotton Belt are now upon a far sounder and more permanent basis than formerly." Again, it may be said that the advent of this destructive weevil of cotton and the control measures recommended as a result of investigations by entomologists was largely responsible for the development of the present day Extension Service which is recognized as one of the greatest aids to present day Agriculture. Quoting again from Doctor Hinds: "In the early years of this investigation it became apparent that certain changes might be made in the usual cotton cultural practices with a good prospect of reducing the damage done by the weevil to the crop. The only way in which planters could be induced to make these changes was to enter into a legal contract, whereby the Department of Agriculture agreed to reimburse them for losses incurred, if they would follow faithfully the practices recommended by the Entomologists and should fail to secure at least as good a yield as they had secured on the average by following their own methods on the same

ground during the three preceding years. These contracts were multiplied until more than 50,000 acres of cotton were being grown in this way by 1904. The soundness of the recommendations, which were all cultural, is shown by the fact that in no single case was reimbursement ever called for.

"The demand for a greater extension of these beneficial cultural practices throughout the weevil-infested area, and even in advance of weevil infestation, became so great that in the spring of 1904, Dr. Seaman A. Knapp was placed in charge of the organization of 'The Farm Demonstration Work' 'Farm Demonstration Agents' were appointed by counties to show the farmers who were willing to cooperate just how cotton should be raised to offset weevil damage. The beneficial effects of this new type of agricultural service work were so impressive that the demand for it spread far outside of the Cotton Belt, and ten years later it was made National in scope under the Smith-Lever Bill and known since as the Extension Service"

Studies in Florida show that the best and most economical method of controlling the two-spotted mite on *Asparagus plumosus* is through the installation and use of a sprinkling system. The adoption of this practice has proven to be a decided improvement in cultural methods, especially in Asparagus plantations which often suffer severely from lack of water during the dry season. The value of this system has been responsible for its installation and use with profit to the grower aside from its value as a mite control.

The vapor-heat treatment was developed in connection with the Mediterranean fruit fly campaign in Florida. Later it was used effectively to destroy bulb fly maggots and mites attacking narcissus bulbs. The treatment was additionally beneficial in that bulbs so treated showed a more vigorous growth and an additional increase in weight of the resultant crop. Further tests with greenhouse spiraea (*Astilbe* sp.) to control the grubs of the black vine weevil occurring in the root clumps, not only destroyed the grubs but in addition roots thus treated were brought into bloom for Easter Sunday, just 88 days after treatment or nearly a month before untreated specimens. The growth stimulation on the plants where tests have been made was very pronounced and the treatment offers valuable possibilities in addition to insect control.

Methods of forest management developed for bark beetle control have proven better forestry practices aside from their value in controlling the insects in question. For example, the federal Bureau of Entomology studies of the western pine beetle show that this insect attacks trees of slower growth in preference to those of faster growth.

This has brought about a desirable modification in the forest service plans of managing western yellow pine in California.

In house fly control the daily spreading of manure is recognized as the most important step. This method of handling manure is now regarded as the most effective way of preserving the fertilizer value of manure. The increased productiveness of soil, where this practice has been consistently followed, has netted large returns to the farmer.

Since the determination that stable flies breed very largely in straw stacks, a consistent effort has been made to secure better care of straw and the scattering and plowing under of unnecessary straw stacks and the bases of old stacks. The adoption of these practices has resulted in material gain to the farmers in grain-growing regions. A single straw stack may occupy 50,000 square feet and it has been computed that the area covered by straw stacks in Kansas alone is no less than 250,000 acres. The efforts to control the stable fly have, therefore, indirectly resulted in the elimination of considerable waste through the tilling of areas formerly occupied by straw stacks, through the conservation of the straw for bedding and feeding purposes and through the return of a certain amount of the straw to the soil to improve its humus condition

In the control of the screw worm and other blow fly larvae affecting livestock, the most important single step has been the proper disposal of carcasses. This preventive practice has been adopted quite widely and, as a result, such animal diseases as anthrax and black-leg have been reduced and a material saving effected to the livestock interests of the Southwest. The practice of dehorning to prevent injury to animals which ultimately become infested with screw worms has been rather widely adopted and this has proven a distinct advantage to stockmen in the handling, shipping and feeding of cattle. Early lambing is another recommendation made in the control of the screw worm and wool maggot. The production of early lambs, as a result, has made for better prices and, incidentally, for less ill effects from stomach worms among such early lambs.

The adoption of recommended practices, resulting in the elimination of the cattle tick from large areas in the South, has been responsible for many benefits. Among the most noteworthy of these is the improvement in the quality of the livestock due to the introduction of pure-blood animals from the North, which was impossible when the cattle tick was prevalent in the southern pastures. This grading up of the livestock in the South has greatly increased the value and productiveness of the cattle in southern states. Furthermore, the tick control practices have increased the number of animals carried on pastures in the South,

and this in turn has improved the fertility of the soil. The adoption of tick control practices has resulted in the lifting of the quarantine which permits southern stock owners to enter previously prohibited markets, which has been a distinct advantage.

As an essential aid in the control of the spotted fever tick the Montana State Board of Entomology formulated regulations in 1913 for the killing of ground squirrels as tick hosts and the dipping of cattle in the infested Bitter Root Valley. These regulations were at first vigorously combated by the residents of the Valley. It was later recognized that these regulations represented definite benefits in addition to any relation to spotted fever and stockmen are now anxious to dip their cattle and consider it a privilege instead of a legal requirement. Similarly, districts which have never had any spotted fever cases to amount to anything, have requested that the authorities create control districts for ground squirrels

Early irrigation and planting of sugar beets has been found to be helpful in excessive injury from the sugar beet leafhopper. These practices recommended for beet leafhopper control have become regular practices, not only in the leafhopper infested areas but elsewhere in the irrigated districts, because of their value in beet culture regardless of the insect

In reviewing the whole field one becomes amazed at the vast application of entomological research and then when we add to this direct benefit the indirect values which have been briefly referred to and finally the value of the purely scientific facts covering thousands of printed pages, even the entomologist must marvel over the unbelievable amount of practical and scientific results which the scientifically trained entomologists have obtained in the past 60 years. We have made only a beginning in these threescore years but with the accomplishments in this short period of time we can anticipate even more rapid accomplishments during the next 60 years.

PRESENT STATUS OF TWO ASIATIC BEETLES (*ANOMALA ORIENTALIS* AND *AUTOSERICA CASTANEA*) IN THE UNITED STATES[1]

By HAROLD C HALLOCK,[2] *Associate Entomologist, U. S. Bureau of Entomology*

ABSTRACT

The oriental beetle (*Anomala orientalis* Waterh.) is generally limited to an area within 90 miles of New York City, but the Asiatic garden beetle (*Autoserica castanea* Arrow) is found at widely separated localities from Massachusetts to Virginia. Both species in the larval or grub stage cause destruction to lawns, but only the Asiatic garden beetle is injurious to plants in the adult stage. Adult feeding of this species is most extensive on ornamental plants and often results in complete defoliation The grubs of both species in lawns are controlled by an application of 15 pounds of lead arsenate to 1,000 square feet. For the Asiatic garden beetle a spray of 6 pounds of coated lead arsenate to 50 gallons of water, or 3 pounds of lead arsenate and 2 pounds of flour to 50 gallons of water, is recommended.

About 12 years have now elapsed since two Asiatic beetles were first found in the United States; the oriental beetle[3] (*Anomala orientalis* Waterh.) was discovered in 1920 and the Asiatic garden beetle (*Autoserica castanea* Arrow) in 1921. Both species have evidently found conditions well suited to their rapid increase, as their favored food plants are abundant, climatic conditions are favorable, and, so far at least, no native parasites have been observed impeding their increase.

With respect to dispersion, however, the oriental beetle has not kept pace with the other species, having spread relatively little, while, on the other hand, colonies of the Asiatic garden beetle are rather widely scattered over a considerable area. At the present time (November, 1932) the oriental beetle has been found generally only in southwestern Connecticut, southeastern New York, and northwestern New Jersey, with 3 small isolated infestations near Albany, N. Y. (Fig. 4). The area infested by the Asiatic garden beetle is very much larger and includes parts of Connecticut, Delaware, the District of Columbia, Maryland, Massachusetts, New York, New Jersey, Pennsylvania, and Virginia. This area may be roughly subdivided as follows (Fig. 5): A zone of continuous infestation about New York City, extending in New York State north to White Plains and east to Jericho, and in New Jersey west to Paterson, Caldwell, and Summit. Beyond this area there is a zone of

[1]Contribution No. 113 from the Japanese Beetle Laboratory, Moorestown, N. J.

[2]The writer desires to acknowledge his appreciation of many helpful suggestions made by Dr. J. M. Hawley while this paper was being prepared.

[3]This insect has been known as the Asiatic beetle but the name has been changed to avoid confusion.

discontinuous or localized infestations, many of which are widely separated The air-line distances from the center of the dense infestation (New York City and vicinity) to the most distant points where beetles have been found are approximately as follows: north 90 miles (Kingston,

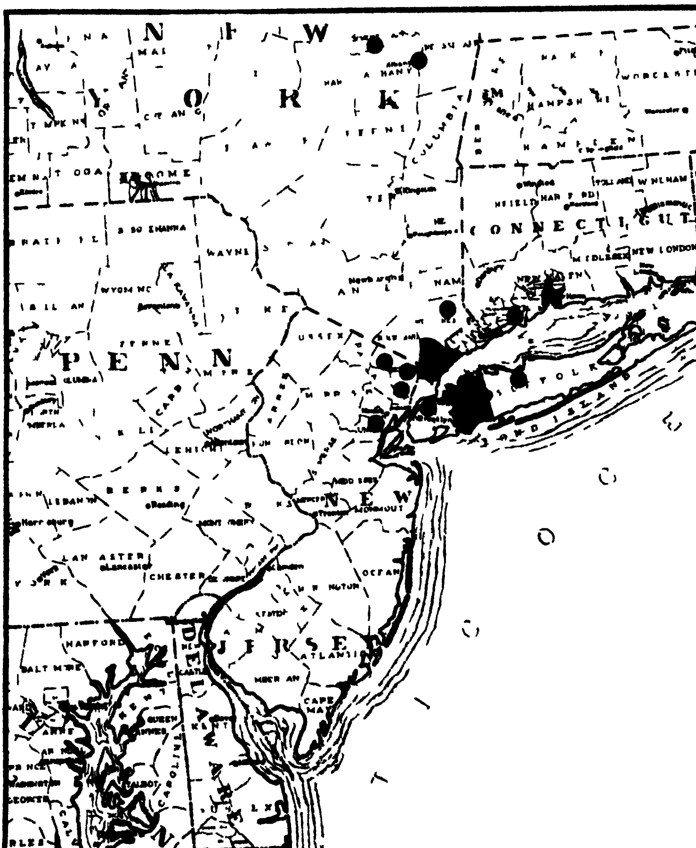


FIG. 4 — Distribution of oriental beetle in 1932

N. Y.), northeast 135 miles (Agawam, Mass.); east 130 miles (New London, Conn.); south 215 miles (East Falls Church, Va.); and west 150 miles (Towanda, Pa.) and 290 miles (Somerfield, Pa).

The difference in the rate of spread of the two species may be due in part to a variation in the time and method of flight of the adults. The oriental beetle flies only in bright sunlight on very warm days, and even on such days flight is largely limited to a process of flitting about close

to the surface of the ground. In these flights beetles have been rarely observed to travel as far as 50 yards without stopping.

On the other hand, the Asiatic garden beetle is a night-flying insect that, when the temperature is 70°F. or above, flies about in large numbers and for great distances. In the vicinity of New York City there are few nights when this favorable temperature prevails, and yet the natural spread has been several miles a year.

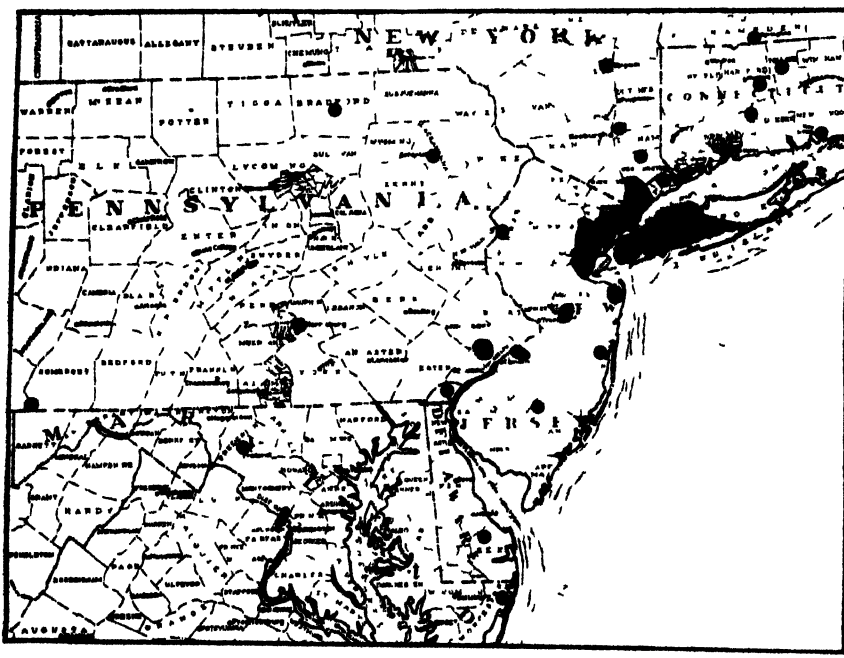
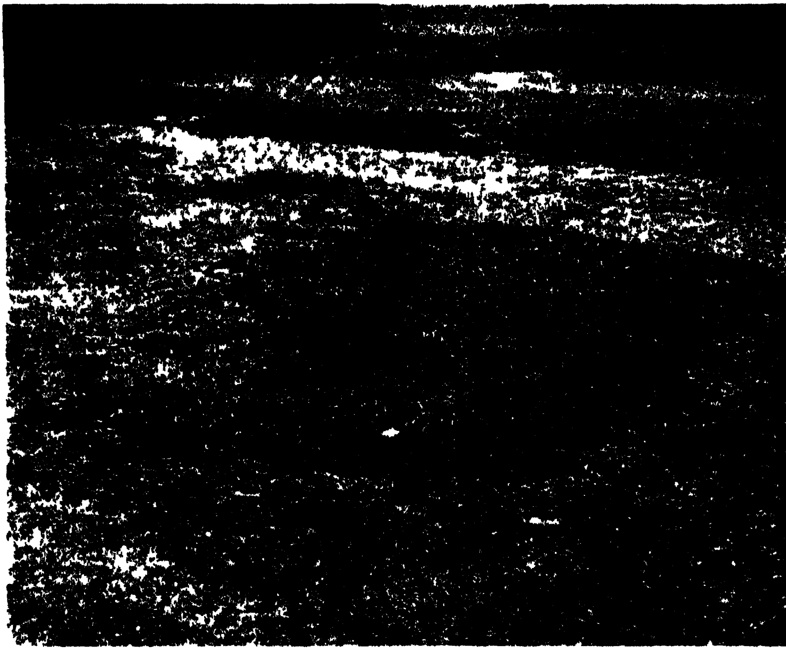


FIG. 5.—Distribution of the Asiatic garden beetle in 1932.
(In this map are included distribution data received from L. H. Worthley, Bureau of Plant Quarantine, which were secured by road inspection.)

There is a difference in grub habitats that may have a still more important influence on the extent of spread of the two species. Grubs of the oriental beetle are normally abundant only in well-kept lawns, while grubs of the Asiatic garden beetle occur in all types of sod-land, in weed patches, and to some extent in cultivated areas such as gardens and nurseries. When grubs occur in these latter situations, they may easily be carried out of the infested area by the movement of plants with soil about the roots. It is probable that many of the widely scattered colonies of this insect were started in this way.



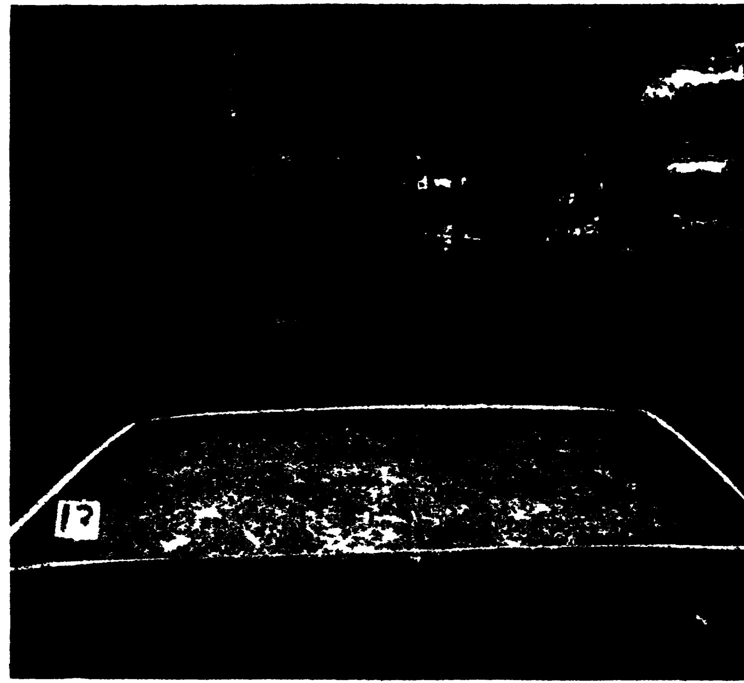
1 Injury to turf by grubs of oriental beetle

2 -Injury to strawberry plants by grubs of the oriental beetle

1 Injury to chrysanthemum (Shasta daisy) blossoms by the Asiatic garden beetle

2 Injury to phlox by the Asiatic garden beetle

1—Injury to peach foliage by the Asiatic garden beetle



2 Control of grubs of the Asiatic beetles. Plot No 13 is a check plot while plots in front and back were treated with lead arsenate

Our present knowledge of these two pests does not permit a definite prediction of their probable behavior as they move into new territory. However, one factor that may influence the future activity of both species is that a shortage of soil moisture, especially at the time eggs are developing, will result in a high mortality. The summers of 1929 and 1930 in the New York area were dry, and it has been estimated that by the close of the latter year there had been a reduction of at least 60 per cent in the Asiatic garden beetle population from that of 1928. It seems probable, therefore, that these beetles may not thrive in many inland places where the summer rainfall is much below that of New York City, although both species would thrive in parts of the Southern States where the rainfall is adequate. The oriental beetle has been reported by Swezey[4] as a pest of sugarcane in Hawaii, and it should thrive where similar climatic conditions exist in this country. Since the Asiatic garden beetle on Long Island feeds voraciously on hot nights and scarcely at all on cool nights, it would be expected that, other conditions being equal, plant destruction would increase as the insect moves south and encounters higher temperatures.

The adult oriental beetle feeds sparingly on grass blades and the flowers of such plants as rose, hollyhock, phlox, dahlia, and Japanese iris, but this feeding is never extensive enough to cause appreciable injury. It is only in the larval or grub stage that the oriental beetle is definitely destructive. In heavily infested districts, as locally exemplified near New York City, 40 to 60 grubs to the square foot are often uncovered in lawns. In such instances the turf is entirely destroyed (Pl. 1, fig. 1). The most severe injury in other situations has been found in strawberry beds (Pl. 1, fig. 2), where in some places as high as 90 per cent of the plants have been destroyed.

The injury caused by the adult Asiatic garden beetle has been more severe than that caused by the oriental beetle. Observations during the past six summers have shown that the Asiatic garden beetle will feed on more than 100 species of plants, though the preferred food plants number only about 20. In the adult stage the beetle is primarily a pest of ornamental plants. The varieties of shrubs most commonly attacked are rose, devils-walkingstick, butterflybush, viburnum, and boxelder. The most favored flowers are those of such plants as aster, all varieties of chrysanthemum including the Shasta daisy, dahlia, delphinium, gaillardia, hemp, sunflower, and strawflower. In these plants both blossoms and leaves are attacked (Plate 2). With the exception of peach (Pl. 3,

[4]Swezey, O. H. Present status of certain insect pests under biological control in Hawaii. Jour. Econ. Ent. 21: 669–676, 1928 at page 672.

fig. 1) and cherry, which are sometimes defoliated, fruit-bearing trees and shrubs are rarely attacked. Injury to truck crops appears to be mostly limited to rhubarb and carrot.

In addition to the destruction caused by the adults of the Asiatic garden beetle, the grubs often cause considerable injury. This is for the most part confined to the turf of lawns, but in recent years injury to the roots of certain ornamental plants, such as aquilegia, begonia, chrysanthemum, and sedum, has become increasingly noticeable. In gardens, grubs have been found feeding, to some extent, on the roots of such plants as young beets, carrots, onions, and corn, but they appear more particularly to relish those of strawberry plants, of which in some instances as high as 75 per cent have been destroyed in old beds.

The method of grub-proofing lawns and golf courses developed for the Japanese beetle has given excellent control of grubs of the oriental and the Asiatic garden beetles.[5] In experimental field tests at Jericho, N. Y., complete protection from both species has been secured in treated plots, while turf on adjoining untreated or check plots has been completely ruined (Pl. 3, fig. 2). It is recommended that lead arsenate be used on established lawns at the rate of 15 pounds per 1,000 square feet. On the other hand, in the case of a new lawn, where the infestation is very heavy, it is advisable to apply lead arsenate at the rate of 35 pounds per 1,000 square feet and mix it in the soil to a depth of 3 inches.

The adult oriental beetle feeds very little and causes no appreciable injury to plants. There is, therefore, no necessity for control during this stage. In the case of the Asiatic garden beetle, however, the problem is more difficult. Since a satisfactory repellent for adults of this latter species has not been developed, the foliage of plants can not be completely protected in cases of heavy beetle infestations, as the ornamental gardens are often reinfested several times during the beetle season, even sprayed foliage being completely consumed by successive waves of invading beetles. On the other hand, in cases of moderate infestation, where there is little likelihood of repeated reinfestation, a spray of 6 pounds of coated lead arsenate to 50 gallons of water, or 3 pounds of lead arsenate and 2 pounds of flour to 50 gallons of water, has given good results as a stomach poison and will give adequate protection.

On warm nights, when the Asiatic garden beetles are in actual flight, they are strongly attracted to electric lights. Taking advantage of this

[5]For further information on the methods of treatment of turf for the control of grubs, see Fleming, W. E., and Osburn, M. R., Control of Larvae of the Japanese and the Asiatic Beetles in Lawns and Golf Courses. U. S. Dept. Agr. Cir. 238, 11 pp., illus. 1932.

habit, a light trap has been developed in which a 500-watt daylight bulb is suspended above a metal funnel 3 feet in diameter at the top. Beneath the small end of the funnel there is a pail of water with a film of oil into which the beetles fall. A trap of this type at Westbury, N. Y., has often captured from 1,000 to 10,000 beetles in a single night, and on one very warm night in the 1928 season 21,000 beetles were taken. It is interesting to note that, although a daylight bulb is more attractive to beetles than a clear bulb, tests carried on in the laboratory during the past summer seem to show that a violet light, produced either by a color screen or a quartz mercury vapor lamp, is much more attractive to the insect than a daylight bulb

Although this trap has captured many beetles, it is believed that at present it is not sufficiently perfected to be recommended as a satisfactory means of control

THE EUROPEAN CORN BORER SITUATION IN THE UNITED STATES AT THE CLOSE OF 1932

By D. J CAFFREY, *Senior Entomologist, Division of Cereal and Forage Insects, U. S. Bureau of Entomology*, and L. H. WORTHLEY, *Principal Administrative Officer, European Corn Borer and Japanese Beetle Division, U. S. Bureau of Plant Quarantine*

ABSTRACT

New infestations of the corn borer (*Pyrausta nubilalis*) discovered during 1932 were confined to a very few localities located chiefly along the margin of territory formerly known to be infested.

The 1932 infestation survey revealed an increase in borer population amounting to approximately 6 per cent in the surveyed territory of the North Central States area, when compared to the borer abundance in the same counties during 1931. A similar survey in the Eastern States area disclosed a decrease of approximately 2 per cent in the borer population of the territory surveyed, when compared to the last survey conducted in the same counties in 1930. Distinct commercial loss from corn borer attack occurred to field corn in eastern Michigan and northwestern Ohio, and to both field and sweet corn in the Lake Ontario district of New York, eastern Massachusetts, southern Rhode Island, and eastern Long Island.

Experimental results obtained with the more effective insecticides tested have shown the feasibility of such applications to corn and dahlias of high market value, as a protective control measure.

Approximately 5,200,000 imported parasites have been liberated during the last 13 years. Several species are known to have become permanently established. Field-recovery records during 1932 indicate that the total parasitization by such species ranges from less than 1 per cent to 50 per cent in different localities.

Preliminary experiments indicate that the commercial application of new facilities for refrigeration may be successfully and economically employed in the low-temperature sterilization of ear corn infested by the corn borer.

Field tests have shown that certain varieties and strains of corn are more resistant and tolerant to corn borer attack than others. The plant characteristics associated with tolerance and resistance are being sought. Plat experimentation in "damage" tests have shown that for each additional borer in an infested plant there occurs, on an average, a corresponding, correlated reduction in yield.

New Infestations of the European Corn Borer Discovered During 1932

During the season of 1932, scouting operations were conducted as in previous years along the periphery of the area quarantined up to July 15, 1932. The scouting consisted of a very thorough examination of cornfields in the townships or districts adjacent to the former quarantined area as well as in and around the infestations discovered in 1931 in the "Eastern Shore" of Virginia. In addition, the scouting work was extended to include the examination of portions of Maryland, Illinois, and Wisconsin, in cooperation with State agencies. The spread of the corn borer during 1932, as revealed by the scouting operations, was confined to a very few new infestations, located chiefly within a comparatively short distance from formerly known infested territory The following townships and districts were first found infested in 1932: *Virginia*—Lee and Metompkin districts in Accomac county; *Pennsylvania*—Nockamixon, Bridgeton, and Tinicum townships in Bucks County; *Maryland*—the districts of Newark No. 4, Snow Hill No. 2, Colbourne No. 6 and Stockton in Worcester county: and Williards district No. 14 in Wicomico county; *West Virginia*—Union township in Marion county; *Kentucky*—Section No. 4 in Campbell county; *Indiana*—the townships of Indian Creek in Pulaski county; Wheatfield in Jasper county; Jackson, Manchester and Lawrenceburg in Dearborn county; Adams in Ripley county; and Washington in Tippecanoe county; *Wisconsin*—Mt. Pleasant township in Racine county.

Status of Infestation and Crop Loss

North Central States (One-Generation): In the area of the North-Central States, comprising the infested portions of Michigan, Indiana, Ohio, Pennsylvania, and New York, K. W. Babcock, in charge of the population project, reports that the annual survey to determine corn borer abundance, in the late summer of 1932, demonstrated that within the entire surveyed territory there had occurred, on an average, an increase in the borer population present in the same territory (counties), namely from 31.7 borers per 100 plants in 1931 to 33.5 borers per 100 plants in 1932.

This survey was conducted in cooperation with various State agencies principally in those counties where during preceding seasons the population had averaged 5 or more borers per 100 plants. Certain adjacent counties not previously surveyed were added owing to their strategic corn-growing importance. A total of 114 counties, involving 2,955 cornfields, were included in the survey.

The more important points developed during the 1932 survey, together with indicative comparisons with similar surveys in the same counties which have been examined each year since 1925, are shown in Table 1, and in the following discussion taken from Mr. Babcock's report:

TABLE 1. COMPARISON OF EUROPEAN CORN BORER POPULATIONS IN THE TERRITORY SURVEYED OF THE NORTH CENTRAL STATES AREA FROM 1925 TO 1932. (BASED UPON COMPARISONS OF COUNTY AVERAGES FOR EACH YEAR)

State	Number of counties surveyed	Borers per 100 plants in— 1925	1926	1927	1928	1929	1930	1931	1932
Michigan	6	1.4	23.6	64.7	45.2	31.1	22 6	32.8	51.6
Indiana	4	*	*	*	0.5	0.9	1.6	7.9	5.3
Ohio...	12	6.3	28.3	20.0	33.8	35 8	11.6	30.2	32.4
Pennsylvania	1	13.7	41.7	73.4	9.7	17.3	5.4	2.5	8.3
New York .	8	1.5	10.8	13.0	27.3	10.9	28.4	48.6	38.7
Area average**	31	3.5	19.7	26.0	29.3	23.4	16.6	31.7	33.5

*No survey conducted, but for purposes of computing an area average zero infestation in these years has been used.

**Area average obtained by totalling the individual county averages and dividing by the number of counties.

In further elaboration of the points brought out in the infestation survey it may be stated that in comparison with conditions in 1931

1. An increase in the numerical abundance of the corn borer occurred during 1932 in Michigan, Ohio, and Pennsylvania, whereas decreases occurred in New York and Indiana.

2. Marked increases of population developed in the "thumb" counties of Michigan.

3. The population remained practically unchanged in the counties bordering the southwestern and eastern shores of Lakes Erie and Ontario, in the central portion of the northwestern Ohio section, and in Lenawee County, Mich.

4. Significant decreases have occurred in Crawford County, Ohio; Hillsdale County, Mich.; Steuben County, Ind.; and, in the Albany district, Monroe, Wayne, and Wyoming Counties, N. Y.

5. The major trend of borer concentration seems to be southward in Ohio, following the distribution of extensive acreages of good corn production. Preble County was the only "corn" county surveyed which did not reveal infestation in the 30 fields examined. Champaign County, Ohio, has a surprisingly high borer population (8.1 borers per 100 plants) for a county near the known southern border of infestation, and located approximately 100 miles from Lake Erie.

6. In Indiana the chief concentration of borers is in DeKalb and Allen Counties

Mr. Babcock reports that the principal influences that may account for the slight increase observed in numerical abundance of the corn borer in the 1932 corn crop of the North Central States area were as follows:

1. A greater number of overwintering borers survived in the corn residues in the spring of 1932 than in 1931 (2.04 versus 1.62 borers per 100 plants), as revealed by the débris survey.

2. A greater number of eggs were deposited in 1932 than in 1931 (1,824 versus 482 eggs per 100 plants), according to data from the egg survey. Favorable weather conditions for egg deposition and vigorous corn were the chief features contributing to the increase in numbers of eggs.

3. Immediately following the peak of the egg laying, drought conditions, known to be extremely unfavorable to corn borer development, became prevalent. This resulted in a high mortality of eggs and young larvae that extended throughout Michigan, Indiana, Ohio, Pennsylvania, and the extreme western counties of New York, (Chautauqua and Erie). In the more easterly counties of New York, general seasonal conditions were reversed as compared to the other parts of the one-generation area. Here the distinctly unfavorable weather conditions prevailing during the period of moth flight were followed by excellent conditions for larval survival. On an average, and based upon the data from all counties where the egg survey was conducted, the larval survival in 1932 was 14.1 per cent (i. e., number of mature borers developing from each 100 eggs deposited) as compared to 21.3 per cent in 1931 and 5.4 per cent in 1930.

By reference to Table 1 it will be noted that throughout the 8-year period from 1925 to 1932, inclusive, there occurred a fluctuation from year to year in corn borer abundance. This situation has developed despite severe handicaps imposed upon the insect by large-scale public and private "cleanups" in 1926, 1927, and 1928, aided by exceptionally adverse weather conditions, reducing the survival of the borer in 1930, and to a slightly more limited extent in 1932. During 1930, according to Weather Bureau records, a combination of deficient precipitation and excessively high temperatures at critical periods of the season, were more adverse for an insect like the corn borer than in any season during the preceding 29 years.

The greatest concentration of borers and resultant crop loss in the territory surveyed during 1932 were found in three districts in the North Central States; (1) the northwestern Ohio counties of Wood, Sandusky, Hancock, Henry, Lucas, Ottawa, Putnam, Seneca, Fulton, and Erie; (2) the eastern Michigan counties of Monroe, Macomb, Wayne, Sanilac, Tuscola, Lenawee, and Washtenaw and (3) the Lake Ontario district of New York in the counties of Oswego, Jefferson, Ontario, Wayne, Monroe and Orleans. Commercial damage occurred in these three districts, and the present large corn borer population there constitutes a source of

potential danger for 1933 in the event of average weather conditions for the development of the insect. In other portions of North America and in the Old World it has been observed that the borer can increase in one year to from 4 to 6 times the population of the previous year.

In the northwestern Ohio district the infestation was characterized by a slightly heavier concentration of borers in the relatively early planted fields than occurred in 1931. The maximum borer population in any field under observation was approximately 10 borers per plant, with an estimated commercial loss of 30 per cent of the crop. In three other fields in this district the population ranged from 5.6 to 8.6 borers per plant, with estimated commercial losses ranging from approximately 15 to 25 per cent of the crop. There were a great many fields in the Ohio counties listed above where superficial examination indicated that the borer population ranged from 3 to 5 borers per plant. In such fields the injury and economic loss due to corn borer attack was visually evident The borer density in the adjacent counties of Williams, Defiance, Paulding, Van Wert, Allen, Hardin, Wyandot, Crawford, Huron, and Lorain was approximately two-fifths of that in the counties containing the maximum concentration for the northwestern Ohio district.

In the eastern Michigan district substantial losses were suffered to field corn, particularly in the counties of heaviest infestation Two fields of this district, representing the maximum borer population, average 5.4 and 6.8 borers, respectively, per plant, with estimated commercial losses of 15 to 20 per cent of the crop Seven other fields of this district, where data were obtained, ranged from 2.6 to 3.8 borers per plant, with estimated commercial losses ranging from 7.5 to 10 per cent of the crop.

In the adjacent counties of Oakland, Lapeer, St. Clair, Huron, Genesee, Jackson, Livingston, Ingham, and Hillsdale the borer density was, on an average, one-third that in the counties most heavily infested in this district.

In the Lake Ontario district of New York substantial losses were suffered by growers of sweet corn, particularly in the counties Oswego, Jefferson, Ontario, Wayne, Monroe and Orleans, with less serious but appreciable damage to field corn and silage corn. A special sweet-corn survey by K. R. MacLowry of the Toledo, Ohio, laboratory, in the Silver Creek, Hamburg-Eden, and Genesee River Valley sweet corn sections, disclosed only slight infestation and crop loss caused by the corn borer in the early-planted fields. However, the infestation and crop loss were pronounced in the late-planted fields.

With respect to infestation and crop loss to field corn in the Lake

Ontario district, a 2-acre field representing the maximum infestation observed in the district contained an average of 11.4 borers per plant, with an estimated crop loss of approximately 34 per cent. Several other fields under observation contained 2 to 4 borers per plant, with estimated crop losses ranging from 6 to 12 per cent.

In the remainder of the northwestern New York district covered by the survey, comprising the counties of Niagara, Genesee, Wyoming, Erie, Chautauqua, and Cattaraugus, the borer density was approximately one-fourth of that in the counties representing the maximum concentration for the district. In the eastern New York district, under the survey, comprising the counties of Albany, Rensselaer, Saratoga, Schenectady, Fulton, Montgomery, and Schoharie, the borer density was approximately three-fourths of that in the most heavily infested counties in the Lake Ontario district.

EASTERN STATES (TWO-GENERATION). In the Eastern States area, comprising the infested portions of New England, eastern Long Island, and east-central New Jersey, A. M. Vance reports that the infestation survey during the late summer and early fall of 1932 revealed an average infestation of 103.6 borers per 100 plants, as compared with 105.6 borers per 100 plants in 1930 in the same general territory. No area-wide survey was made in the two-generation area in 1931 because of lack of funds. The 1932 survey, conducted in cooperation with the States of Connecticut, New Jersey, and Vermont, covered a total of 33 counties and included 1,095 cornfields.

The more important points developed during this survey, together with indicative comparisons with similar surveys in the two-generation area since 1925, are shown in Table 2, and in the following discussion, as taken from Mr. Vance's report. It should be explained that the data shown in Table 2 are really not adequate for valid comparisons on the area basis during the 8-year period involved for the following reasons: (1) Lack of funds prevented sufficiently extensive surveys during certain years of this period, (2) the territory of measurable infestation available during the first three years of the period was restricted, (3) changes in survey policy and methods were made during the period, (4) field surveys in the early years of the period were extremely localized in scope. All of these factors militated against planning area-wide surveys in the two-generation area that would allow accurate comparison of the status of the corn borer over a long period of years during which the insect was disseminating rapidly into new territory.

TABLE 2 COMPARISON OF EUROPEAN CORN BORER POPULATION IN THE EASTERN STATES AREA FROM 1925 TO 1932 (BASED UPON COMPARISONS OF STATE AVERAGES FOR EACH YEAR)

State	Number of counties surveyed*	Borers per 100 plants in— 1925	1926	1927	1928	1929	1930	1932
Connecticut	2	—	—	0	3 0	18 7	15 8	44 8
Maine	2	—	—	—	—	2 8	5 6	20 0
Massachusetts	7	68 9	44 7	54 7	237 2	201 6	205 0	162 2
New Hampshire	3	3 0	0 5	0 1	2 5	15 6	4 6	19 9
New Jersey	4	—	—	—	—	—	—	0 6
New York†	1	—	—	—	—	49 4	77 9	394 4
Rhode Island	4	—	13 5	32 8	202 5	187 4	52 3	93 3
Vermont	6		—		—	—	—	11 6
Area average‡	16				155 2	140 3	105 6	103 6

*Applies to 1928 to 1932 only
†Suffolk County Long Island N Y (two generation)
‡Area averages where shown for the period 1928 to 1932 are based upon only those counties which were surveyed in each of the years The average is obtained by totalling the data for the comparable counties and dividing by the number of counties No averages have been shown for 1925 1926, or 1927, since the number of samples from States and counties surveyed in those years were not sufficient properly to represent the entire area for the total period shown (1925–1932) Sixteen counties in the States of Connecticut Massachusetts New Hampshire and Rhode Island are used in computing the area average

The principal facts concerning the 1932 status of the insect in the two-generation area are as follows

1 The major trend of borer concentration appears to have persisted along the Atlantic seaboard of Massachusetts and Rhode Island, southeastern Connecticut, and the eastern half of Suffolk county, Long Island, N Y

2 A rather generally distributed infestation was found in southwestern Vermont in 1932, probably an extension of the one generation strain of the insect from the adjacent New York sections

3 A zone of very light infestation was apparent between the eastern and western portions of southern New England, probably joining the hitherto known areas occupied, respectively, by the two-generation and one-generation strains "

4 Several features of the 1932 status of the insect in the two generation area are of special economic interest (a) The increase in intensity of infestation that occurred on eastern Long Island again demonstrates the potentialities of the corn borer in field-corn habitats Also, this infestation is of extreme importance as a source of corn borer dissemination to the immediate Atlantic seaboard (b) The marked increases in Connecticut counties resulted in distinct though undetermined losses to the breeders and growers of special seed corn This development is of more than local interest, since the several large seed-corn growers located in this State ship their product to many distant points (c) That the corn borer is definitely established in New Jersey was shown by the measurable infestation found in the county-wide surveys of Monmouth and Ocean Counties This source of infestation will probably facilitate the further extension of the two-generation "strain" into the important field-corn, sweet-corn, and vegetable-growing sections of adjacent or near-by New Jersey, Delaware, Maryland, Virginia, and southeastern Pennsylvania

Mr. Vance reports that the principal factors affecting the numerical abundance of the corn borer in 1932 in the surveyed portion of the Eastern States area may be summarized as follows:

1. Favorable weather conditions existed during the dormant period of the borer in the late fall, winter, and spring of 1931-1932.

2. A large number of overwintering borers survived in the corn and other plant residues, as revealed by the débris survey in the spring of 1932, and also in the "stacks" of corn fodder commonly found in eastern Long Island. The absence of extensive débris surveys prior to 1932 prevents comparison of these data with those of previous years.

3. In general, weather conditions were favorable for egg deposition by both generations, according to data secured in the egg survey, conducted for the first time in 1932.

4. Assembled data indicate a high larval survival of both generations in Massachusetts, Connecticut, and Rhode Island, based upon records from districts where the egg survey was conducted. Absence of extensive egg surveys in preceding years renders it impossible to make comparisons of egg abundance and larval survival in 1932.

Two districts in the Eastern States area were found to have high concentrations of borers and resultant crop losses in the territory surveyed during 1932: (1) The Massachusetts-Rhode Island district along the Atlantic seaboard comprising the counties of Essex, Middlesex, Norfolk, Plymouth, Bristol, and Barnstable in Massachusetts, and the counties of Newport, Bristol, and Kent in Rhode Island; and (2) the eastern half of Suffolk county, Long Island, N. Y. Distinct commercial damage occurred in these two districts.

In the Massachusetts-Rhode Island district, the earliest planted sweet corn was heavily infested by the first-generation borers, commercial damage being observed particularly in Bristol county, Mass., and in Newport county, R. I., where the total loss from unmarketable ears caused by corn borer damage ranged from 10 to 50 per cent of the crop in five of the more heavily infested fields under observation. The maximum second-generation population in any field of sweet corn under observation in this district averaged 6.2 borers per plant, with an estimated commercial loss of at least 50 per cent of the crop. The population in 13 other fields of sweet corn in this district, ranged from 4 to 5.4 borers per plant, with estimated commercial losses ranging from approximately 32 to 45 per cent of the crop. In 34 other fields of sweet corn surveyed in the counties listed above, the borer population ranged from 2 to 3.9 borers per plant, and in such fields the injury and loss due to corn borer attack was visually evident. Although sweet corn predominates in this district, many fields of flint and dent corn grown for grain, as well as silage corn, were encountered in following the random

field sampling methods of the survey, especially in the southern portion of the district. One field of dent corn revealed 9.3 borers per plant, with an estimated commercial loss of 28 per cent, and in nine other fields of dent corn the population ranged from 1 to 3.5 borers per plant. One field of flint field corn carried a population of 2.4 borers per plant, and another field of this corn averaged 1 borer per plant. The average in 11 fields of silage corn ranged from 1.1 to 5.4 borers per plant.

The counties of Rockingham and Hillsboro, N. H.; Worcester, Mass.; Providence and Washington, R. I.; and Windham and New London, Conn., which adjoin the district just discussed, had approximately one-fifth of the borer density in the counties containing the maximum concentration for the area. In the remaining counties of the Eastern States area surveyed in Maine, New Hampshire, Vermont, Massachusetts, and Connecticut, the borer density averaged approximately one-twelfth of that in the center of the district. It is interesting to note that in the counties of New London and Hartford, Conn., outside the district representing the maximum concentration of the insect, seven fields of flint field corn held from 113 to 532 borers per 100 plants, and two fields of dent field corn contained 153 and 182 borers, respectively, per 100 plants. A few fields of sweet corn grown for seed in southern Connecticut suffered appreciable although undetermined economic losses.

In the Suffolk County, Long Island, district, the first-generation infestation and crop loss to early sweet corn was essentially the same as has been detailed for the Massachusetts-Rhode Island district. Field corn predominates in Suffolk County, the 1930 agricultural census reporting a total of 7,803 acres of corn in the county, of which 61.5 per cent consisted of field corn grown for grain or fodder, 12.0 per cent corn grown for silage, and 26.5 per cent sweet corn. In the 1932 second-generation survey, the random field sampling methods were carried out in 14 fields of dent (field) corn, 54 fields of flint (field) corn, 2 fields of silage corn, and 20 fields of sweet corn. The maximum second-generation borer population in any field of flint corn under the survey in this district was an average of 57 borers per plant, resulting in the total loss of the crop on the 1.7-acre field. Four other fields of flint corn in this district carried borer populations ranging from 11 to 19.6 borers per plant, sustaining estimated commercial losses ranging from at least 33 to 60 per cent of the crop. Nine additional fields of flint corn contained from 6.2 to 9.5 borers per plant, with estimated commercial losses ranging from at least 19 to 29 per cent of the crop. Eighteen other fields of this same type had borer populations ranging from 2.2 to 5.9 borers

per plant, with corresponding estimated crop losses. Among the fields of dent corn examined, there were 11 with populations ranging from 2.3 to 8.2 borers per plant, with estimated commercial losses ranging from 7 to 25 per cent of the crop. Five fields of sweet corn in this survey contained from 1.9 to 8 borers per plant, with estimated commercial crop losses ranging from 15 to 64 per cent of the crop.

Mr. Vance conducted a special midsummer survey to determine the first-generation infestation of sweet corn in a total of 150 fields distributed throughout five subdistricts in southern Connecticut, in Newport County, R. I., and in the counties of Suffolk and Nassau, Long Island. In these fields there were found, on an average, 1.3 borers per plant, and 11.4 per cent, of the ears produced in such fields were unmarketable on account of corn borer damage. A special second-generation survey in 30 fields of lima beans in the eastern portion of Suffolk County (Long Island) revealed 8.8 borers per 100 plants, the infestation principally resulting from direct egg deposition upon the lima bean plants, as disclosed by a prior egg survey. A similar special survey of lima beans in midsummer had failed to locate any first-generation infestation in the plants. In this same district an examination of 30 potato fields in midsummer showed an average first-generation population of 22.8 borers per 100 plants. An egg survey in 30 potato fields of this district had disclosed 3.7 egg masses per 100 plants, as a result of deposition by the first brood of corn-borer moths.

Natural Enemies. Approximately 613,000 imported corn borer parasites were liberated in the infested areas of the United States during 1932, including 18 different species. Included in this total were approximately 8,000 parasites which were obtained by large-scale recovery collections at points in the infested areas where the imported parasites are becoming sufficiently numerous to warrant this procedure. For the 13-year period 1920 to 1932, inclusive, a total of approximately 5,200,000 of these parasites have been liberated. Twenty species of parasites from Europe and the Orient have been represented. Fourteen of these have been recovered in the field under circumstances indicating their possible permanent establishment.

D. W. Jones and his associates at the Arlington, Mass., laboratory report that field collections of the overwintering 1931–32 generation to determine the parasite population in 41 typical towns of the Eastern States area revealed 8.26 per cent parasitization in the samples collected from 12 of these towns in the general vicinity of the liberation points, and that parasitization ranging from 0 to 23.3 per cent, as an average per town, was found and an average of 7.3 per cent for the entire group.

During the summer of 1932, collections of the summer generation in 40 towns demonstrated percentages of parasitization ranging from 0 to 49.75 per town, with an average for the entire group of 10.68 per cent, based upon the samples examined. Field collections prior to special "bulk collections" in 10 fields of one town showed 10 per cent parasitization, on an average. The same type of collections in 9 fields of six towns in the same general section revealed 13 per cent parasitization on the same basis.

In the North Central States area (one-generation) W. A. Baker and his associates at the Monroe, Mich., laboratory report that the parasite-recovery collections of 1931 indicated a total parasitization by the imported species ranging from a trace to 16 per cent in the immediate vicinity of nine of the more important liberation points. Five of the imported species predominated in these recoveries. The observations for 1931 revealed continued field maintenance, without support of additional liberations, of three species of parasites imported from Europe (*Chelonus annulipes* Wesm., *Inareolata punctoria* Roman, and *Masicera senilis* Rond.) that had previously exhibited strong initial capabilities of establishment. These three species represent an excellent parasite sequence in attacking the egg, the larva in the early instar, and the larva in the later instars, respectively. While complete data indicating for 1932 the field status of parasites in this area will not be available until the early spring of 1933, excellent initial establishment is indicated for two species of parasites (*Macrocentrus gifuensis* Ashm., and *Cremastus flavoorbitalis* Cam.) imported from the Orient and released in the one-generation area for the first time in 1932

In 1932 K. A. Bartlett of the Arlington, Mass., laboratory made field tests and liberations of the fungous disease *Beauveria bassiana* (Bals.) Vuillemen in the two-generation area and in the one-generation area, under widely divergent environmental and seasonal conditions, with the objective of determining the utility of this disease as an aid in the natural control of the corn borer. The original spore material of *B. bassiana* was secured from infected larvae of *P. nubilalis* received from the Orient in the course of parasite importations.

EXPERIMENTS WITH INSECTICIDES. Results obtained through experiments with insecticides during the last four seasons have demonstrated the practicability of applying the more effective insecticidal materials to corn of high market value as a protective corn borer-control measure. The experimental work upon this subject has involved an exhaustive testing of a large number of such materials as gave any promise

of effectiveness. In general liquid insecticides have proved more effective than dust applications.

C. H. Batchelder of the Arlington, Mass., laboratory reports that in 1932, under the two-generation conditions existing in the Eastern States area, from three to five applications of either nicotine tannate or lead arsenate in a 1 per cent paraffin-oil emulsion resulted in a 65 to 80 per cent reduction of the borer population in sweet corn. A consistent reduction was secured in the number of larvae infesting all ears of the treated plats, in comparison with the untreated plats, accompanied by an increase in the number of borer-free ears. In instances where the paraffin oil was applied in excessive quantities, however, the number of salable ears in the treated plats was less than in the untreated plats.

These investigations are being continued, emphasis being placed upon large-scale field tests and upon the perfection of the paraffin oil-lead arsenate and the nicotine tannate combinations, the determination of the best time and method of application with respect to the seasonal development of the plant and the corn borer, and the relation between the growth habit and general physiology of different varieties of corn as they affect spray coverage.

Under one-generation conditions, Dr. Batchelder conducted repeated tests upon field corn at Toledo, Ohio, with the more promising insecticides employed in the two-generation area The general results secured under these conditions were similar to those mentioned for the two-generation area.

F. L. Simanton of the Monroe, Mich., laboratory reports that the tests of 1932 with various insecticides upon dent field corn at Monroe and at Toledo, Ohio, under one-generation conditions, revealed that best results were secured with 6 pounds of calcium fluosilicate compound in 100 gallons of a 2 per cent summer oil emulsion. This material produced a control of 85 per cent with a single application and 83 per cent with two applications, expressed in terms of reduction of the larval population of the respective plats. Other insecticides giving promising results were potassium fluosilicate with summer oil, barium fluosilicate with summer oil, and sodium fluoaluminate. The insecticide investigations in the one-generation area are being continued along the same general lines mentioned for the two-generation area, emphasis being placed on an intensive study of the performance of the more promising materials and to large-scale field tests.

Doctor Batchelder obtained very satisfactory protection from infestation and injury to dahlias, in experimental tests during the season of 1932, by employing a spray which consisted of barium fluosilicate in a

0.4 per cent paraffin oil-emulsion. Five applications of this material to dahlias which were exposed to severe infestation increased the number and quality of the blooms, reduced stalk injury 83 per cent, and resulted in a 97 per cent decrease in the infesting borer population, when compared to that of the untreated plats. Nicotine-tannate in a 0.4 per cent paraffin oil-emulsion, used in the same plat series, resulted in appreciably less satisfactory control (54 per cent decrease in stalk injury and 78 per cent reduction of borer population)

Investigations of Lethal Low Temperatures to Corn Borer Larvae in Dry Ear Corn

The feasibility of cold sterilization as applied to dry ear corn was tested in late May, 1932, by C. H. Batchelder and D. D. Questel in a series of unique experiments. Employing a two-station, cold-plate freezer, the thermal decline of the central portion of the cob pith of dry seed ears of Canada Leaming field corn was measured when the ears were subjected to —20.0° F. A surprising feature of the data obtained was the regular and somewhat rapid descent of the temperature. While in *green* ears of Whipples Yellow sweet corn 4 hours is required to reach zero (F.) in the cob pith, under similar conditions the cob-pith center of the dry ears of Canada Leaming reached zero in 70 minutes. The difference is largely explained by the low moisture content of the drier ears (14.12 per cent), and due to this a very small amount of latent heat to be overcome in bringing the cob pith to subfreezing temperature levels. The thermal decline of *green* ears is characterized by a period of retardation in the progress of heat loss owing to the latent heat of the contained water. Such a retardation period is absent in the thermal decline of dry ear corn. During a 3-hour exposure of this dry corn to —20°F. the temperature at the center of the dry cob-pith dropped to —18°F. The experiments indicated that no obstacle would be met during efforts to obtain —40 or —50°F. at the cob-pith center should methods of cold sterilization be applied to corn.

In dry ear corn, retarded fifth instar, hibernating larvae of the European corn borer were found to be affected by subzero temperatures. "Quick freezing" at —20°F. by means of a plate froster was fatal to these infesting larvae during a 3-hour exposure, and a 48-hour exposure of ear corn to —20°F. in a cold room also killed infesting larvae.

The temperatures employed had no apparent deleterious effect upon the germinating capacity of the seed. (Moisture content of ears employed in the test was 14.12 per cent.) Samples from exposed ears gave

in a "rag-doll" test 100 per cent germination of seed exposed for 48 hours in a cold room and 96 per cent germination when plate-frosted.

The experiments, although of a preliminary nature, indicate that the commercial application of new facilities for refrigeration may be successfully and perhaps economically employed in cold sterilization of dry corn products with special reference to the European corn borer.

LARVAL SURVIVAL AND RESISTANCE AND TOLERANCE OF CORN. Continued field tests during 1932 of commercial varieties and special strains of field and sweet corn, by L. H. Patch of the Sandusky, Ohio, laboratory and Morris Schlosberg of the Toledo laboratory, in cooperation with the agronomists, corn breeders, and soils specialists of the Illinois and Ohio Agricultural Experiment Stations, the Illinois State Natural History Survey, and the U. S. Bureau of Plant Industry, have demonstrated consistently that certain of the corn varieties and strains were more resistant to the corn borer than others, as expressed in terms of relatively low larval survival (i. e. number of mature borers developing from each 100 eggs deposited) when grown under equivalent conditions of exposure to corn borer infestation, soil type, soil productivity, and other contributing cultural influences. The hybrid strains possessing marked resistance have been consistent in this characteristic from year to year. The inbred strains which were crossed to produce the hybrids appear to carry genetic or inherent characteristics of resistance or susceptibility to corn borer infestation. The larval survival on all the hybrids produced by using in the crosses the most resistant inbred strains so far developed has averaged for 3 years 46 per cent less than the larval survival on all the hybrids produced by using in the crosses the most susceptible inbred strain noted to date. The hybrids exhibiting the maximum resistance of all the strains tested in 1931 and 1932 also have produced the highest yields of any strains in the group tested. The hybrids containing the most resistant inbred strain have been, on an average, one day later in silking than the hybrids containing the most susceptible inbred strain. Investigations in cooperation with various specialists will be continued in an endeavor to determine the plant characteristics associated with the mortality of the borer on resistant and susceptible strains of corn, with the objective of utilizing this feature as an aid to corn borer control.

Mr. Hodgson of the Arlington, Mass., laboratory has started similar work, under two-generation conditions, particular emphasis being devoted to tests with commercial varieties and special strains of sweet corn.

In order to judge the economic value of any particular variety or

strain of corn, as an aid to corn borer control, it is necessary to consider the tolerance as well as the resistance of such varieties or strains to corn borer attack. For our purpose the most important factors of "tolerance" may be defined or measured in terms of the yield and quality of the crop and the degree of stalk breakage due to the presence of corn borer infestation. With an equal number of borers per plant, the yield of a tolerant strain of corn is typically greater than the yield of a less tolerant strain, even though the yield of both strains might be the same in the absence of infestation. The relative tolerance of varieties or strains is measured by the difference in the rates at which the yields decrease with increasing mean borer populations. A significant relation has been found between the reduction in yield per borer per plant for certain of the tested strains, and the normal yields of such strains; in general the higher yielding strains suffered the greater reduction per borer per plant.

A review of the reports of Messrs Patch and Schlosberg for 1932, as well as their reports for previous years, leads to the definite conclusion that certain of the varieties and strains tested have exhibited more tolerance to corn borer attack than others, but that this tolerance may or may not be combined with resistance.

In certain of these tests, conducted in cooperation with the agencies mentioned previously and with the U. S. Bureau of Agricultural Engineering, an important factor of tolerance appeared to reside in the rigidity or ruggedness of the stalk, which permitted the stalks of certain of the high-yielding strains to escape with a minimum of breakage below the ear, thus allowing the ears every opportunity for complete development, and later contributing to efficient harvesting by hand or machinery owing to the upright position of the stalks. These results were secured in experimental plats where varying levels of borer population were induced by artificial infestation. It is hoped that continued investigation of the influences affecting tolerance to corn borer infestation in the corn plant will lead to an economic utilization of the results in corn borer control.

In B. E. Hodgson's work at Arlington in 1932, the first year of this type of investigation in the two-generation area, no appreciable differences were noted in the resistance or tolerance of the six varieties tested.

Experiments to Determine Optimum Planting Date for Corn Borer Control. Experiments were begun in 1931 and continued in 1932 by L. H. Patch and his associates at the Sandusky laboratory in an attempt to determine the factors bearing on the optimum planting date for corn borer control. The results of these tests to date give indications

that the lower borer populations on later planted corn, as compared to earlier planted corn, whether caused by a smaller deposition of eggs or by a lower larval survival, result in a much greater reduction in yield per borer per plant than do equivalent borer populations in the earlier planted corn. This indicated greater damage per borer in the later planted corn, combined with the normal reduction in yield ordinarily suffered from later planting, offsets to a great extent the advantage of the lower borer populations usually developing in later planted corn.

EXPERIMENTS TO DETERMINE DEGREE OF DAMAGE. Field experiments were continued in 1932 by Mr. Patch at Sandusky and by Mr. Schlosberg at Toledo, in cooperation with the agencies mentioned previously, with the objective of relating borer population to the degree of damage occasioned by the corn borer when infesting widely divergent typical or special types, varieties, and strains of field and sweet corn under different conditions of soil type and soil productivity In other words, this project is designed to yield information enabling us ultimately to translate figures upon borer population into terms of crop loss, with proper allowance for the variations in loss caused, per borer per plant, due to varietal differences and different cultural and environmental conditions affecting the growth and yield of corn

Essentially the plat technique in these tests consists of manually infesting replicated, uniform-sized, and adjacent plats of corn with a sufficient number of corn borer eggs to produce progressively higher levels of borer population per plant. In each series, one of the plats contains natural infestation only, but otherwise receives the same treatment as the manually-infested plats. Usually the series of progressive levels of borer population has consisted of adjacent plats containing an average of approximately 5, 10, 15, 20, and 30 borers, respectively, per plant, accompanied by a plat containing natural infestation only. In some of the field tests additional or different ranges of borer population levels have been employed. Since the same variety of corn in any of the principal series is all planted on the same date, in practically uniform soil, receiving a uniform fertilization, and given the same cultural treatment throughout the season, this technique accounts for all measurable variables excepting the numbers of borers per plant. Moreover, the plats are replicated to adjust possible minor soil differences and to enable proper adjustments of any other possible minor variables that may develop. Separate and supplementary tests of the same general type are conducted to determine variations that may develop under different conditions of soil type, soil productivity, soil fertilization, and as a result of different planting dates.

In the two-generation area Mr. Hodgson of the Arlington laboratory has followed essentially the same field technique as has been detailed for the one-generation area in experiments to determine the degree of damage per borer per plant to sweet corn, with the same objective as previously described.

Analysis of the data available from these experiments to date indicates that within the range of borer levels studied (up to approximately 30 borers per plant) the rate of increasing loss per borer per plant is similar at low or high borer levels. Expressed in another manner, for each additional borer per plant there occurred a corresponding reduction in yield. Also, these studies reveal that the loss per borer per plant varies slightly with the strain, variety, and type of corn, in general a greater loss being sustained per borer in small types of corn than in medium sized or large types The magnitude of loss for the same varieties varies with soil and climatic conditions, date of planting, date of deposition of eggs, and such cultural practices as influence the vigor and productiveness of the corn plants.

Under average soil conditions, in medium sized field corn of the dent type planted during the mid-season planting period, the commercial loss in grain production has averaged approximately 3 per cent per borer per plant (based upon the average number of borers per plant in 100 plants). In field corn of smaller size the loss per borer has been slightly greater than that indicated above, whereas for the larger sized field corn the loss per borer has been slightly less than the indicated figure. In general, the loss per borer has been markedly greater in soils possessing a relatively high degree of productivity, whether secured by fertilization or inherent in the soil, than the loss per borer in poorer soils, although the greater yields secured under the better soil conditions have more than compensated for the greater loss per borer. Also, the loss per borer in the late-planted field corn has been significantly greater than in mid-season or early planted corn. In the instance of sweet corn, the loss in weight of marketable ears has averaged approximately 8 per cent per borer per plant. Variations in loss per borer in sweet corn have followed practically the same trend as have been detailed for field corn of the dent type.

DR. GLENN W. HERRICK (Ithaca, New York): How do you account for the slight spread around the periphrey of infested areas?

DR. CAFFREY: Dr. Bacheler found nocturnal temperatures were below the point of favorable activity of the moths. Moreover, the prevailing winds during that period were from the Southwest which

tended to prevent extensive flight. In general, it was, as I mentioned at the beginning, a question of very unfavorable conditions during the period of moth flight.

THE 1932 GRASSHOPPER OUTBREAK

By J. R. PARKER, *Bureau of Entomology, Bozeman, Montana*

ABSTRACT

Unfavorable weather conditions, disease and parasites during 1932 reduced grasshoppers in Iowa, Nebraska and South Dakota to such an extent that crop damage was far below that of 1931. In Minnesota, infestations were greatly increased over the previous year but a well organized control campaign prevented extensive crop losses. North Dakota suffered heavier crop losses from grasshoppers than any other state. Precipitation records in areas having heavy egg infestations in the spring of 1932 showed minus departures at stations where outbreaks were as serious as predicted and plus departures where damage was less than expected.

During the spring months of 1932, the United States Senate three times approved a bill appropriating $1,450,000 for grasshopper control. In the House of Representatives the item was disapproved an equal number of times. In view of the prolonged congressional debates on grasshopper control and the extensive publicity given it in the press, it seems desirable to present a brief record of grasshopper conditions during the past summer in the States for which relief was asked.

ACKNOWLEDGMENTS. In preparing the summary of conditions, the following men were consulted and many of the statements are based on correspondence or conversations with them. Colorado—F. T. Cowan, Deputy State Entomologist; Iowa—Dr. C. J. Drake, State Entomologist; Minnesota—Prof. A. G. Ruggles, State Entomologist; T. Aamodt, Assistant State Entomologist; Montana—Dr. A. L. Strand, State Entomologist; J. H. Pepper, Assistant State Entomologist; Nebraska—Prof. Myron H. Swenk, Entomologist of the Nebraska Experiment Station; O. S. Bare, Extension Entomologist; North Dakota—Prof. J. A. Munro, Professor of Entomology, North Dakota State College; F. D. Butcher, Extension Entomologist, Insect Pest Survey, U. S. Bureau of Entomology; South Dakota—Prof. H. C. Severin, Entomologist, South Dakota Experiment Station; A. L. Ford, Extension Entomologist, South Dakota State College. Personal first-hand information was obtained by extended trips through the most heavily infested areas during the entire period of grasshopper activity.

COLORADO. Control campaigns were necessary in 12 counties in the eastern half of the State. The heaviest infestations were in Prowers and

Kit Carson Counties. No State or county funds were used but approximately $15,000 was spent by individual farmers in purchasing materials to make poisoned bran mash. Control campaigns were organized by county agricultural agents, working under the direction of the State Entomologist or his assistants. Prompt application of standard control measures prevented serious crop damage. The principal species in the order of their importance were: The two-striped grasshopper (*Melanoplus bivittatus* Say), the differential grasshopper (*M. differentialis* Thos.), and the red-legged grasshopper (*M. femur-rubrum* De G.).

IOWA Grasshoppers hatched in large numbers in counties along the western boundary of the State. The heaviest infestations were in Plymouth, Woodbury, Monona, and Harrison Counties. The State purchased 250 tons of commercially prepared poisoned-bran mash and sold it to the farmers at $10 per ton, which was 50 per cent below cost. Farmers were organized by the State Entomologist and his assistants very early in the season. The young grasshoppers were poisoned on their hatching grounds, and as a result there was no serious crop damage. Heavy rains and an abundance of sarcophagid flies were also important factors in checking grasshoppers during the remainder of the season. The principal species present were *Melanoplus differentialis*, *M. bivittatus*, *M. mexicanus* Sauss., and *M. femur-rubrum*.

MINNESOTA. Red River Valley Counties in western Minnesota experienced the most serious grasshopper outbreak that has occurred in that region since the days of the Rocky Mountain grasshopper. Hatching in great numbers started on May 13. Dry, warm weather favored their survival and grasshoppers were soon numerous enough to threaten complete destruction of all crops. The State Entomologist and his assistants had expected the outbreak and had a complete organization ready in every county to meet the emergency. State funds were used for the purchase of supplies; mixing, transporting, and scattering of bait were done by the county organizations. Large-scale poisoning was started as soon as the young hoppers began to invade crops and was pushed intensively throughout the month of June. The campaign against the wingless hoppers was remarkably effective and allowed early flax and small grains to mature with but slight losses. Poisoning operations slackened as the small grain harvest approached and nearly every grain field soon had a large population of adult grasshoppers, many of which had flown in from surrounding territory. The cutting of grain and hay crops and the drying of weeds and native grass in early July forced the grasshoppers to move to green crops such as late flax, corn, and potatoes, which up to this time had escaped with little injury. The

heavy concentration of grasshoppers on such crops resulted immediately in serious damage. State and county leaders sounded the alarm, bait-mixing plants were reopened, and poisoning operations resumed with the result that further damage to crops was largely prevented. It was the opinion of farmers, county agents, county board members, and business men in western Minnesota that total destruction of crops over large areas would have resulted if no control measures had been employed.

In addition to the major outbreak in the Red River Valley, minor infestations threatened crops in many other parts of the State. A total of 56 counties received State aid in the form of commercially-prepared poisoned bran mash, or materials for making the home-mixed bait, which had cost approximately $235,000.

The species of grasshoppers concerned in the outbreak in the order of their importance were: *Melanoplus bivittatus*, *Camnula pellucida* Scudd., *M. femur-rubrum*, and *M. mexicanus*.

MONTANA. Grasshoppers hatched in sufficient numbers to threaten crops in 15 counties. The heaviest infestations were in Dawson, Richland, and Roosevelt Counties in northeastern Montana, and in Fergus County in the central part. Some counties furnished arsenic and molasses to farmers without cost; others bought materials in large lots and sold to farmers at cost. Approximately $8,000 was spent in the State for materials used in making grasshopper bait. An efficient campaign conducted early in the season by the State Entomologist and the county agents prevented serious crop losses.

The most important species were *Melanoplus mexicanus*, *M. bivittatus*, and *M. packardii* Scudd.

NEBRASKA. Nebraska experienced a serious grasshopper outbreak in 1931 and expected even more trouble in 1932, but the actual damage was decidedly less than in the previous year. A tremendous hatch occurred in May and June as predicted, but heavy, beating rains destroyed millions of the little hoppers. Many more were killed by fungus during the hot, wet weather of late June and July, and by sarcophagid flies which appeared in great numbers during August. Early and extensive use of poisoned-bran mash helped to bring the outbreak under control but without the aid of natural factors it is doubtful if control could have been secured with the money that was available. Consensus of opinion agreed that, had natural conditions favored the grasshoppers as they did in 1931, crops over a large part of the State would have been severely injured and damage would have mounted into millions of dollars.

Areas of heaviest infestation and most serious damage to crops were Brown, Keyapaha, Boyd, Holt, Knox, Cedar, and Antelope Counties in northeastern Nebraska, and Logan, Loup, Custer, Dawson, and Buffalo Counties in the central part. Grasshoppers were present in more than normal numbers in 65 of the 90 counties in the State. Twenty carloads of poisoned-bran mash were bought with State funds and distributed among 19 counties. In most cases State funds were matched by the counties, but many counties purchased bait in carload lots without State aid. In approximately two-thirds of the counties in which grasshoppers were fought, all materials were bought by individual farmers at their own expense. No exact figures are available but it is estimated that from 75 to 100 carloads (2,000 tons) of poisoned-bran mash were used during the campaign.

The most important species were *Melanoplus bivittatus*, *M. differentialis*, *M. femur-rubrum*, and *M. mexicanus*.

NORTH DAKOTA. North Dakota suffered heavier crop losses than any other State in the 1932 grasshopper outbreak. There was no extension or field entomologist to organize counties and communities in preparation for the expected outbreak, and no State money was available for the purchase of poisoned bran mash. Control measures were left to the counties, and little was done until after the grasshoppers had hatched and were invading crops. After the seriousness of the situation was realized, the State College extension staff and the entomologist on the teaching staff worked to the limit of their ability in aiding counties which had appropriated money for grasshopper control. The Bureau of Entomology also sent an extension entomologist into the State to aid county agents in organizing control campaigns.

Hatching in great numbers began on May 13 and continued until about June 10. Owing to delays in appropriating money and in securing supplies, poisoning operations were not started in most counties until the first week in June. Young grasshoppers had then started to invade crops and considerable damage had been done. Counties which went ahead with intensive campaigns were able to save small grains without serious losses. In many counties, however, the amount of poisoned bran mash that one farmer could get was limited to as little as 100 pounds to each 160 acres of cropped land, with the result that little protection to crops in heavily infested fields was obtained and losses ranged from slight to total. When haying and grain harvesting began, grasshoppers concentrated on green crops such as flax, corn, and potatoes, doing serious damage in these crops which up to that time had escaped with but little injury.

Of the grain crops, oats and barley suffered the most and early-maturing wheat the least. In one county during one week's time, 250 farmers having Government seed loans obtained permission to cut their grain for hay in order to save it from further grasshopper injury. This was a common practice in many parts of the State. Flax was severely damaged, the loss over the entire State averaging from 35 to 40 per cent. Conservative estimates of the average loss caused by grasshoppers to all crops range from 15 to 20 per cent of the total yield.

Areas of heaviest infestation were Towner, Cavalier, Pembina, Benson, Ramsey, Walsh, and Grand Forks Counties in the northeastern corner of the State; Cass and Ransom Counties in the southeast; Bottineau, Renville, Ward, and Burke Counties in the northwest; Golden Valley, Hettinger, and Adams Counties in the southwest. Thirty-eight of the 52 counties in the State appropriated money for grasshopper control. The amounts ranged from a few dollars to as high as $25,000 in a single county—the total for all counties being approximately $110,000.

The most important species in the outbreak were *Melanoplus bivittatus*, *Camnula pellucida*, *M. mexicanus*, *M. femur-rubrum* and, in the southwestern corner of the State, *M. differentialis*.

SOUTH DAKOTA. In deciding what should be done in preparation for grasshopper control in 1932, South Dakota entomologists faced a most difficult problem. Large areas had been completely devastated by grasshoppers the previous year, and from egg surveys it appeared that an even more destructive outbreak might occur in 1932. State money for control was not available and county treasuries in the grasshopper infested areas were so badly depleted that an organized, large-scale poisoning campaign was impossible unless Federal aid could be obtained The plan decided upon was a publicity campaign during the winter and early spring months advising farmers to increase their acreages of grasshopper-resistant crops, such as kafir and cane, and to make every effort to secure early maturity in small grains—experience in 1931 having shown that early maturing crops often escaped serious injury even when great numbers of grasshoppers were present. If Federal aid could be obtained, a poisoning campaign was to be conducted; if not, further control of grasshoppers after they had hatched was to be left to nature. Federal aid was not obtained but nature did more than the most optimistic had expected.

During May, there were two periods of 4 to 6 days each when maximum temperatures ranged from 85° to 95° Fahrenheit. At these temperatures, grasshoppers hatched in such numbers that they seemed to

boil from the ground. Each warm spell was terminated by driving rains which dashed the tiny hoppers into the mud and washed them into streams, and this was followed by several days of cold, wet weather which further increased the mortality. Weather conditions during the remainder of the season were frequently favorable to fungus and bacterial diseases which attacked grasshoppers in many parts of the State. By mid-summer, Sarcophagid flies had increased to large numbers and were decidedly more effective than disease in cutting down grasshopper populations

Grasshoppers which survived the early unfavorable weather found a luxuriant growth of weeds and native grasses close to their hatching grounds, and as a result crops were not invaded to any great extent until small grains began to ripen. In many fields the ripening grain was stripped of its foliage but despite this the heads filled well. Wheat attacked in this manner often yielded 20 to 25 bushels per acre. Early grain crops in general escaped with but slight loss. Some late seeded grain, particularly oats and barley, was badly damaged during July, the ground in many fields being covered with a mat of severed heads and fallen stems. After grain and hay were cut, grasshoppers concentrated in corn, flax, and potatoes, and in some parts of the State did considerable damage to these crops, particularly to corn. Crop statisticians estimated the average grasshopper damage to all crops at approximately 5 per cent, which would represent a monetary value of $200,000 at present farm prices.

Areas of heaviest infestation and most serious damage to crops were Potter, Sully, and Hughes Counties in the center of the State, Lyman, Tripp, Mellette, Gregory, and Charles Mix Counties in the south, and Spink and Clark Counties in the east. Only one county in the State appropriated money for grasshopper control and there was very little poisoning done by individual farmers.

The most destructive species, in the order of their importance, were *Melanoplus bivittatus*, *M. differentialis*, *M. femur-rubrum*, and *M. mexicanus*.

Rainfall in Grasshopper Infested Areas. It has been stated that unusually heavy rains during the hatching period were unfavorable to grasshoppers in Iowa, South Dakota, and Nebraska, and that dry weather was favorable to grasshoppers in Minnesota and North Dakota Precipitation records for May and June from five U. S. Weather Bureau stations in counties where enormous numbers of eggs were present at hatching time are given for each State. It will be noted that total departures from normal for the two months' period are all minus in

Minnesota and North Dakota In Iowa, Nebraska, and South Dakota total departures are all plus with the exception of Onida in Sully County, South Dakota It is perhaps significant that in Sully County grasshopper damage was more severe than in any other county in South Dakota

RAINFALL RECORDS FOR MAY AND JUNE FOR 1932

(In Inches)

State and county	Town	Total rainfall May	Total rainfall June	Departure from normal May	Departure from normal June	Total for period	Total departure from normal
IOWA							
Plymouth	Akron	5 71	4 69	+1 74	+0 19	10 40	+1 93
Harrison	Little Sioux	5 25	7 35	+1 34	+2 83	12 60	+4 17
Harrison	Logan	5 24	6 44	+1 24	+1 80	11 68	+3 04
Pottawattamie	Oakland	3 88	8 65	—0 02	+3 90	12 53	+3 88
Monona	Onawa	4 30	7 67	—0 05	+2 98	11 97	+2 93
							+15 95
NEBRASKA							
Boyd	Butte	6 99	4 51	+3 76	+0 56	11 50	+4 32
Cedar	Hartington	6 65	4 15	+2 25	—0 17	10 80	+2 08
Brown	Mary	5 06	6 03	+1 90	+2 96	11 09	+4 86
Holt	O'Neil	3 19	6 81	+0 03	+2 97	10 00	+3 00
Keyapaha	Spring View	4 18	6 10	+1 23	+2 56	10 28	+3 79
							+18 05
SOUTH DAKOTA							
Buffalo	Gann Valley	4 60	7 98	+1 60	+4 40	12 58	+6 00
Gregory	Gregory	3 31	6 10	+0 81	+2 70	9 41	+3 51
Lyman	Kennebec	2 64	4 33	+0 16	+1 18	6 97	+1 34
Sully	Onida	2 46	3 82	—0 59	+0 54	6 28	—0 05
Tripp	Winner	3 56	8 06	+1 11	+4 65	11 62	+5 76
							+16 56
MINNESOTA							
Norman	Ada	3 14	1 09	+0 37	—2 66	4 23	—2 29
Polk	Angus	1 59	2 56	—0 83	—0 80	4 15	—1 63
Marshall	Argyle	1 41	2 10	—1 00	—1 45	3 51	—2 45
Polk	Crookston	2 23	1 80	—0 60	—1 72	4 03	—2 32
Clay	Moorhead	2 05	2 16	—0 84	—1 89	4 21	—2 73
							—11 42
NORTH DAKOTA							
Cass	Amenia	2 56	2 47	—0 29	—1 32	5 03	—1 61
Trail	Hillsboro	2 74	1 11	—0 45	—2 31	3 85	—2 76
Walsh	Park River	1 30	2 05	—1 07	—1 43	3 35	—2 50
Grand Forks	Grand Forks	2 30	2 27	—0 31	—1 15	4 57	—1 46
Pembina	Pembina	1 14	4 47	—1 29	+0 87	5 61	—0 42
							—8 75

THE RESPONSE OF CORN EARWORM MOTHS TO VARIOUS SUGAR SOLUTIONS

By L. P Ditman and E. N. Cory, *College Park, Md.*

ABSTRACT

Corn earworm moths (*Heliothis obsoleta*) responded in varying degrees to ten sugars in solutions. On the basis of molar concentrations, sucrose, invert sugar, and fructose proved most attractive in the order named.

In the early work on the control of the corn earworm, *Heliothis obsoleta* (Fab.), such things as lights, fires, the burning of sulfur, mechanical devices, against both the larvae and the adults, the use of bait pails and poisoned sweets were tried. Though much of this work was empirical in nature, any or all of these were at one time or another thought to be effective measures of control, only to be later cast aside by many workers as impractical or useless.

Glover (1) reported favorable results from the use of a bait of vinegar and molasses placed about cotton fields in plates. Later (2) he suggested the use of cobalt in the bait in order to poison all moths visiting it. For a period of 20 to 30 years the recommendation of sweets and poisoned sweets in pails or plates was made by entomologists for the control of the corn earworm. Howard (3) wrote as follows: "Poisoned sweets have been recommended for many years. Mally also experimented in this direction and found a modification of this method was more or less effective." Mally (4) conducted laboratory experiments using a mixture of water, white arsenic, and ordinary table syrup and found that moths would readily partake of these materials. Death resulted in 15 to 45 minutes. Mally (5) published the results of field experiments in which poisoned baits were sprayed on cowpeas planted near or among cotton plants. Baits were made of beer, of vinegar, and of vinegar and molasses; with white arsenic, potassium cyanide, and corrosive sublimate as poisons. He noted that the moths fed on sprayed cowpea vines and also that dead moths were present on the ground the following day. When poisoned liquids were placed in plates on pedestals among sprayed pea vines, moths failed entirely to visit them. Mally stated: "Anyone who has closely observed the feeding habits of the moth can have no hope for any remedy except an actual application upon the food plants themselves." Quaintance and Brues (6) stated that the use of poisoned sweets had been proved by numerous tests "to be of no practical value;" however, they failed to give any indication of the methods used in their experiments. Burdette (7) found that moths could be attracted in large numbers to corn by a spray made up of invert

sugar syrup. Applications were made at dusk and a wind was found necessary for best results.

In going over this brief review of literature it would appear that the use of a poison bait sprayed on the foliage of the host plants of the corn earworm has a possibility of providing a means of control. As Mally pointed out (4), frequency of application and interference by rain may affect its practicability.

One of the problems encountered in this method of control is the determining of the most attractive bait. It is toward this end that experiments on the reactions of moths to various sugars were made.

Minnich (8) described a method of determining the sensitivity of certain lepidoptera to sugar solutions. The method is based on the extension of the proboscis when the tarsi of the insect are brought in contact with the stimulating solution. By administering sufficient water, moths can be brought into a condition in which they will not respond to water but will respond to certain sugar solutions. Abbott (9) in his work on the screw worm fly applied the terms "water sensitized" for individuals responding to water, and "water non-sensitized" to a condition in which individuals no longer respond to water. Similarly in the case of sugar solutions an insect may become sugar sensitive or sugar non-sensitive. Getting the individuals in a water non-sensitive and sugar-sensitive condition makes it possible to determine the minimum concentration to which there is response or the relative response to varying concentrations of different sugars.

In these particular experiments moths were placed in holders within 24 hours after emergence and allowed to remain there until the end of the experiment. A holder consisted of a thin piece of wood (3/16 inches) about ¾ inch wide and 4 inches long, a small piece of cardboard ¾ inch by 1 inch and a rubber band. The moths' wings were drawn together over the back and then placed in the holder between the cardboard and the piece of wood, being held in place by the rubber band. A nail driven through the other end of the wood holder served as a hook by which the holders could be hung along the edge of a shelf, the final result being that the moths were hung suspended in midair. When placed on a sugar diet moths lived as long as 30 days in this position. There was apparently no great difference in length of life of moths in cages and in holders when properly nourished.

Each day moths were given all the water they could drink. Tests to determine sensitivity were always made before trying sugar solutions, only water non-sensitive individuals being used for further experiments. Legs and antennae of the moths were always washed carefully between

tests with distilled water and dried with filter paper. Tests with sugar solutions were usually made between the second and sixth days of life.

Chemically pure sugars and distilled water were used in making up solutions. Solutions were not made up daily, though fresh solutions were made from time to time. All except those of great concentration were kept in a refrigerator at 30° to 32° F. In making a test a small quantity of solution was placed in a micro-culture slide, this in turn being placed below the suspended moth so that its antennae or legs or both came in contact with the liquid. Responses were recorded as slight, medium, or strong, though only strong and negative responses were used in making comparisons between solutions of different sugars. In determining responses of moths to a series of concentrations, the sugar solutions were always tried in ascending strength, that is, from low concentration to high Never more than 15 seconds were allowed for a response, a strong response usually being immediate, and five or more minutes, usually ten, were allowed to elapse between tests on the same series of moths.

RESULTS. The object of these experiments was to determine the preference, if any, of corn earworm moths to ten different sugars in solutions. Comparisons were made on the basis of the relative concentrations of each sugar to which a given degree of response occurred. These experiments were preliminary and intended to separate out the less attractive sugars so that only the more attractive ones need be used in further bait work either in the field or laboratory.

Maltose. Only a few tests were made with this sugar on a series of six moths, three of which died on the third day of the experiment. It was difficult to get maltose into a sufficiently concentrated solution to bring about response. At a temperature of 100 C a solution of maltose approaching 3M concentration was obtained, but began crystalizing on cooling. The results with this sugar were therefore not so satisfactory as desired. To such a supersaturated solution as this moths responded but not, however, so strongly as to much lower concentrations of certain other sugars.

Lactose: Difficulty was experienced in getting a sufficiently concentrated solution. On a series of 10 moths, several of which died during the experiment, practically no response was obtained over a period of six days to the most concentrated solution obtained by the use of heat. This apparently was one of the least attractive sugars.

Sucrose: A total of 70 tests, averaging 7 moths per test, was made at various concentrations on three series of moths, on the first series of which only sucrose was tested. The other two groups were used also for

glucose, fructose, and invert sugar tests. Solutions of sucrose varied in concentration from .001M to .5M. Slight response of a very few moths occurred at the lowest dilution tried, but reactions between .001M and .09M were not constant and varied considerably from time to time. A maximum of reaction was constantly obtained at .3M concentration or above. Tests with a .1M solution often but not always brought about maximum response.

Galactose: A 3M solution was accurately obtained. Seven tests were made on the same series of moths used for lactose solutions, but only an occasional slight response was obtained to even a 3M solution.

Mannose: Four tests were made on a series of 10 moths with 3M mannose. No response was observed at any time.

Fructose: Seventy-seven tests were made, averaging 7 moths per test, at concentrations varying from .1M to 1M. Four series of moths were used, one group being used only for fructose while the other series were used also for other sugars. A general and strong response was sometimes obtained with a .1M solution while at other times no marked degree of response occurred even when the concentration was increased to .6M. An average of all tests showed about 40% response to a .1M solution; response fell away to 20% at .2M concentration, but increased with the increase in concentration thereafter, and at .5M strength, response again passed the 40% mark. This sugar was the most attractive of the monosaccharides used.

Dextrose: Forty-one tests were made on two series of moths, averaging 7 moths to the test. Solutions from .01M to 4M were tried. Only an occasional slight response resulted from tests with lower dilutions. Response became stronger with a 2M solution and reached a maximum at 2.2 to 2.3 concentration.

Arabinose: Four tests were conducted on one series of moths and only in one instance was any response observed even to a 3M solution.

Xylose: Nine tests were made on one series of moths. Slight response was recorded for a 2.8M solution while at 3M concentration a rather general response resulted.

Invert sugar: On a basis of wet weight the particular syrup used contained 43.20% reducing sugar and 78.33% total sugar. Assuming the reducing sugar to be a monohexose and the non-reducing sugar sucrose, a stock solution containing 1.07 molds of sugar per liter was made. On the basis of such calculations the invert sugar was tried in varying concentrations from .043M to 1.07M. Slight reaction was recorded for as low as a .064M solution. A general increase in response was noted as

the concentration increased. Response passed the 50% mark for an average of all tests at .323M concentration.

DISCUSSION: In working out an experiment of this kind certain difficulties are likely to appear. It was noted that all moths do not respond with the same degree of enthusiasm. Occasionally moths, for example, will never cease responding to water while others will never respond even to extremely high concentrations of most attractive sugars. Some moths were always interested in freeing themselves whenever their feet came in contact with any material to which they could hold. Others developed a peculiar condition about the abdomen characterized by hardening and dark color and usually died in a short time. The greatest difficulty of all was experienced in the fact that moths apparently grow tired of responding. This was demonstrated by response to low dilution of sugar followed by a reduction in response to slightly greater concentrations in tests immediately following. Theoretically by increasing the time between tests this factor could have been eliminated, but the number of tests conducted must necessarily have been greatly reduced.

To aid in drawing conclusions as to the attractiveness of these sugars to corn earworm moths, Table 1 is presented.

TABLE 1. SHOWING THE COMPARATIVE REACTION OF CORN EARWORM MOTHS TO DIFFERENT SUGARS IN SOLUTIONS OF GRADUATED CONCENTRATIONS

Sugar	Molar concentration at which reaction was observed			
	No reaction	Occasional reaction	General reaction	Maximum reaction
Lactose	super-saturated			
Maltose			3M?	
Sucrose		.001M- .09M	.1M- .2M	.3M- .5M
Galactose		3M		
Mannose	3M			
Fructose			.1M - .5M?	.6M -1M?
Dextrose		.01M -1.5M	2M -2.2M	2.3M -5M
Arabinose		3M		
Xylose		2.8M	3M	
Invert syrup		.064M- .086M	.097M- .215M	.323M- 1.976M

It can readily be seen that on a basis of molar concentration, sucrose, invert sugar, and fructose are the most attractive. In order accurately to evaluate these three sugars all tests were averaged and these resulting data plotted as a graph. The straight line of closest fit, as determined by the method of least squares, was then worked out for each of the three sugars. These straight lines of closest fit are presented in Figure 6.

Of the remaining sugars, glucose was the most attractive, maltose and xylose were attractive at great concentrations, arabinose and galactose only slightly so, while mannose and lactose caused no reaction.

It must be remembered that the above comparison of attractiveness

of sugars is based on the molar concentrations and that by figuring this relative attractiveness on a per cent by weight basis, the relation between the three most attractive sugars would be different From the data as presented in Figure 6, on a per cent by weight basis these sugars would still be rated in the same order, but the differences would be less.

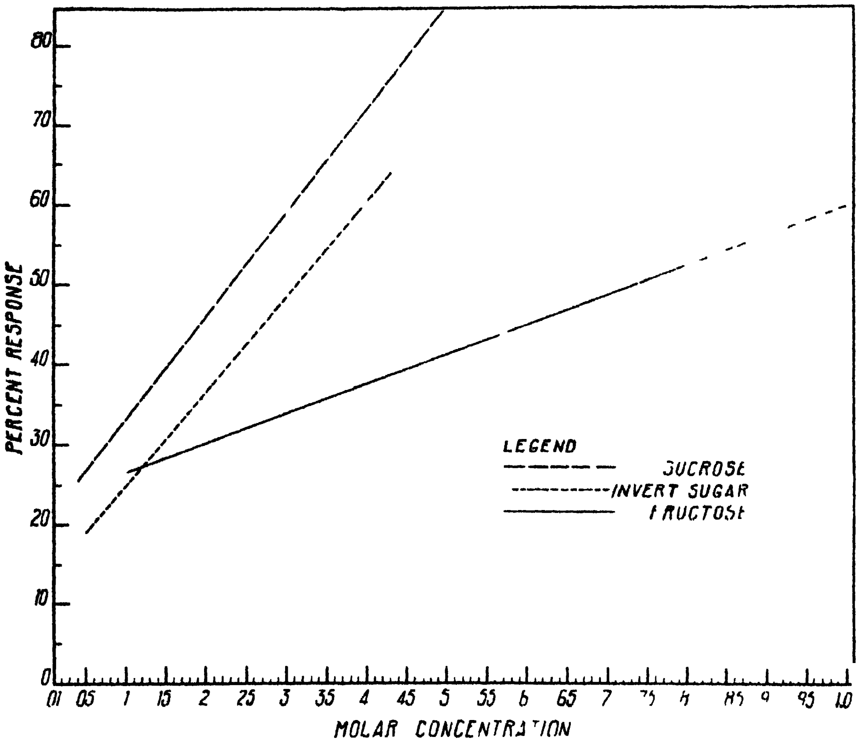


Fig. 6.—The response of Corn Earworm Moths to various concentrations of sucrose, invert sugar, and fructose, as shown by the straight lines that best fit the data

In general, the sweetness of sugars as indicated by the reaction of corn earworm moths does not differ greatly from their sweetness to man as given by Biester et al (10). Man, however, finds fructose sweetest, followed in order by invert sugar and sucrose. The two last both contain fructose. Further experiment may show that earworm moths react in the same order.

It is concluded from these experiments that either fructose or the two fructose-containing sugars, sucrose and invert sugar, may serve equally well as baits for corn earworm moths. The selection of one or another is a question of cost and effective concentration.

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CULTURAL PRACTICES IN RELATION TO MEXICAN BEAN BEETLE CONTROL

By NEELY TURNER and ROGER B. FRIEND, *Connecticut Agricultural Experiment Station, New Haven, Conn.*

ABSTRACT

The effect of spacing of bean plants on injury caused by the Mexican bean beetle (*Epilachna corrupta*) and on effectiveness of control measures is discussed.

The effect of spacing of plants on yields of string beans has received considerable attention. Bailey (1) recommended that bush beans be grown in drill rows, the plants standing 5 to 10 inches apart in the row. Sevey (2) quotes results of various experiment stations showing that drilled rows yield better than hills and that plants spaced 4½ inches apart gave a maximum yield over 3, 6, 9, 12 and 18 inches. Thompson (3) states that garden beans are usually seeded 2 to 4 inches apart, "but 2 inches is too close for any variety. Spacing 4 to 6 inches apart would give better results with most garden varieties." More recently Gillis (4) has reported results of a long series of experiments on the relation between spacing of plants and yields. He concludes that the size and type of plant, amount of rainfall, and soil fertility greatly influence

yields. In spacings from 1 to 4 inches apart in the row he obtained an increased yield in favor of closer planting in every case but one in two-year trials with three common varieties. However, the differences between seeding at the rate of 9 and 12 plants to a foot were generally small. In another report, Gillis (5) concluded that the increases in yield from 1-inch spacing over 1 1/3 inch would not pay for increased cost of seed in all cases. He also called attention to the fact that these rates would apply to very favorable soils.

Nothing definite has been published in regard to the effect of rate of planting on control of the Mexican bean beetle. Howard and English (6) recommended use of varieties producing a small amount of foliage and planting in rows rather than hills in order to aid the effective application of insecticides. Other workers have advised general practices that lead to good growing conditions and quick maturity of the crop.

During the past season the writers have studied the effect of rate of planting string beans in relation to control of the Mexican bean beetle. This report is not complete but gives the results of a single season's study.

Soil. The fertility of the soil influences relative yields from various spacings considerably. These tests were made on the Connecticut Experiment Station farm at Mount Carmel. The soil is Cheshire loam, an upland soil not particularly favorable to bean production. The plot received an application of 5–8–7 fertilizer in April, 1932, at the rate of 2,000 pounds to the acre. The analysis made by the Soils Department of the Connecticut Experiment Station is given in Table 1.

TABLE 1. ANALYSIS OF SOIL FROM BEAN PLOTS

Mechanical	
Colloids	20.5 per cent
Fine sands	40.5
Medium and coarse sands	39.0
Chemical	**Total pounds per acre**
Calcium	10,350
Magnesium	5,196
Potash	23,424
Phosphorus	1,500
Nitrogen	2,010
Available nitrogen	100
Available P_2O_5	200
Reaction pH	7.2

WEATHER. The precipitation for the period of the experiment is given in Table 2. A large deficiency in rainfall accumulated in May, June and July, and the soil was particularly dry during the time the beans were picked.

TABLE 2. PRECIPITATION AT MOUNT CARMEL, 1932

Month	Total precipitation	Deficiency from normal
April	2.825 inches	.695 inches
May	1.700	1.990
June	2.570	.525
July	1.775	2.545
Accumulated deficiency from Jan. 1 to August 1		5.2 inches

EXPERIMENTAL RESULTS. Bountiful and Black Valentine varieties were used in the two series of tests. Bountiful is a common commercial variety and produces a bushy plant with large leaves. Black Valentine is less commonly grown and produces a small compact plant with small leaves. Each variety was planted in 6-row plots, the rows being 10 feet long and 30 inches apart. The spacings were 2, 4, 6, and 8 inches apart in the row. A Latin square arrangement was used, each spacing occurring in four different plots. The seeds were planted by hand and a yardstick was used to insure accurate spacing. All plots were planted May 23, sprouted June 2 and blossomed early in July. Three rows of each plot were sprayed, and three rows left unsprayed. Magnesium arsenate at the rate of three pounds to 100 gallons of water, plus 2 pounds of calcium caseinate, was applied to the under surface of the leaves on June 25 and July 11 for control of larvae. A barrel sprayer and rod with an angle nozzle were used in the application. The amount of spray material used for each series is given in Table 3.

TABLE 3. SPRAY MATERIAL USED—SECOND APPLICATION

Variety	Spacing	Total gallons used
Bountiful	2 inch	10.5
	4 inch	6.0
	6 inch	5.5
	8 inch	6.0
Black Valentine	2 inch	7.0
	4 inch	5.0
	6 inch	3.0
	8 inch	3.0

Black Valentine, being a smaller-leaved variety, required much less spray material, and the 2-inch spacing with each variety required a much larger amount than the other spacings for the same total length of rows.

BEAN BEETLE INJURY. Over-wintering adults appeared on June 6, and some foliage injury was noted June 15. On June 16 a count of the egg-masses present on one row of each of two plots of each spacing was made (Table 4). In the case of Bountiful beans the number of egg-masses on the 2-inch plots was much greater in proportion to the number

of plants than on the 4-inch plots, and in the case of the Black Valentine variety slightly greater.

TABLE 4. EGG-MASS COUNTS—MEXICAN BEAN BEETLE

Variety	Spacing	Number egg-masses
Bountiful	2 inch	32
	4 inch	8
	6 inch	7
	8 inch	4
Black Valentine	2 inch	38
	4 inch	16
	6 inch	14
	8 inch	16

On July 13 the unsprayed plots showed considerable larval injury, the 2- and 4-inch plots being more severely damaged than the 6- and 8-inch plots. On July 29 the 2- and 4-inch plots were defoliated, while the 6- and 8-inch plots were much less seriously damaged.

Yield. The pods were picked by rows, the number of pods and total weight being recorded. Beans of marketable size were picked each time. The pods from the thickly planted plots were small when they were picked, but had reached maximum size. The results are given in Tables 5 and 6.

TABLE 5. YIELD OF BOUNTIFUL BEANS

Spacing	No. plants	Total No. pods	Total yield	Acre yield*	No. pods per plant*	Yield per plant*	No. pods per pound*	Per cent uninjured pods†
				Sprayed				
2 inch	628	7558	59 lbs. 4 oz.	8562 lbs.	12	1.5 oz.	127.5	63
4 inch	322	6635	56 lbs. 4 oz.	8127 lbs.	20.2	2.8 oz.	117.9	93
6 inch	217	5886	54 lbs. 4 oz.	7839 lbs.	27.1	4.0 oz.	108.4	95
8 inch	153	4938	52 lbs. 5½ oz.	7557 lbs.	32.2	5.5 oz.	94.6	93
				Unsprayed				
2 inch	644	5451	40 lbs. 7 oz.	5852 lbs.	8.4	1.0 oz.	134.6	18
4 inch	323	5643	46 lbs. 15½ oz.	6791 lbs.	17.5	2.3 oz.	120.0	23
6 inch	219	5569	51 lbs. 2½ oz.	7398 lbs.	25.4	3.8 oz.	108.8	75
8 inch	169	5289	52 lbs. 13½ oz.	7629 lbs.	30.7	5.0 oz.	100.1	72

*Calculated.
†Second picking.

TABLE 6. YIELD OF BLACK VALENTINE BEANS

Spacing	No. plants	Total No. pods	Total yield	Acre yield*	No. pods per plant*	Yield per plant*	No. pods per pound*	Per cent uninjured pods†
				Sprayed				
2 inch	589	6568	45 lbs. 6 oz.	6560 lbs.	11.1	1.2 oz.	144.6	53
4 inch	287	5807	44 lbs. 9 oz.	6444 lbs.	20.2	2.5 oz.	130.3	79
6 inch	198	5960	49 lbs. 14 oz.	7210 lbs.	30.1	4.0 oz.	119.5	92
8 inch	161	5396	45 lbs. 5½ oz.	6555 lbs.	33.5	4.5 oz.	119.0	85
				Unsprayed				
2 inch	591	6307	41 lbs. 3 oz.	5953 lbs.	10.6	1.1 oz.	153.1	46
4 inch	304	5893	44 lbs. 10½ oz.	6457 lbs.	19.3	2.3 oz.	131.9	64
6 inch	200	5581	45 lbs. 9 oz	6589 lbs.	27.8	3.6 oz.	121.8	78
8 inch	161	4820	40 lbs. 8½ oz.	5865 lbs.	29.9	4.0 oz.	119.0	80

*Calculated.
†Second picking.

These results show some very striking facts. In the case of Bountiful beans, the yield of the sprayed plots increased with the decreased spacing. The differences were not very large in any case, but the trend is very definite. However, the percentage of uninjured pods was very low on the two-inch sprayed plots, and all other spacings yielded a larger amount of clean beans. On the unsprayed series the yields were definitely lower in the case of the 2, 4 and 6-inch plots than in the sprayed series. There was a slight difference in the 8-inch plots in favor of the unsprayed plots, but this was undoubtedly of no significance. The difference may be due to the fact that more plants survived in the unsprayed series. The 8-inch plot produced the highest yield in the unsprayed series, and the yield decreased markedly with closer spacing. This was due to increased beetle injury where the beans were more thickly planted. The 6- and 8-inch unsprayed plots yielded a smaller total amount of pods than the 2-inch sprayed plot, but had a larger percentage of uninjured pods. Figures 7, 8, 9 and 10 show samples from these plots.

It should be noted that the number of pods per plant, total yield per plant and size of pods increased with increased spacing. In the absence of any definite standards for quality in green beans, the writers assume that the appearance and tenderness of the pods govern the quality. The pods from the 2-inch plots were small and tough. The pods from the 4-inch plots were somewhat better, and the pods from the 6- and 8-inch plots were of good quality.

FIG 7.—Sample of pods from sprayed plants 2 inches apart Injured pods at left, clean pods at right

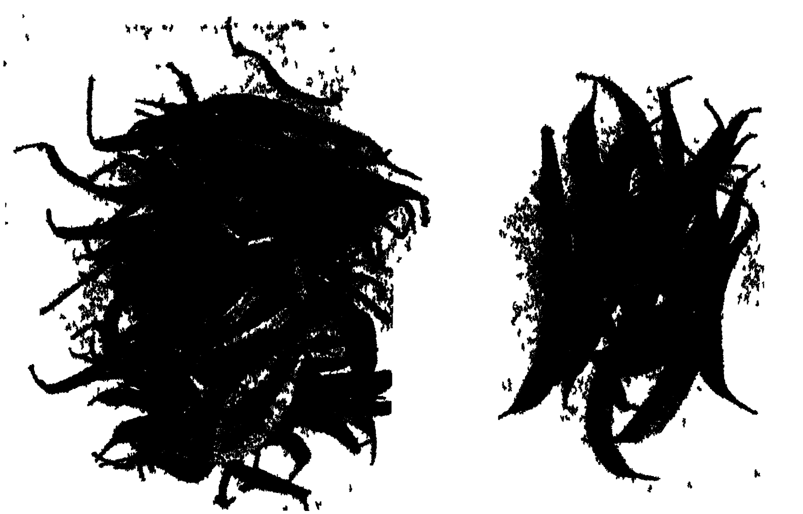

FIG 8.—Sample of pods from unsprayed plants 2 inches apart. Injured pods at left, clean pods at right.

FIG. 9.—Sample of pods from sprayed plants 8 inches apart. Injured pods at left, clean pods at right

FIG. 10.—Sample of pods from unsprayed plants 8 inches apart. Injured pods at left, clean pods at right.

The Black Valentine beans planted 6 inches apart yielded highest in both sprayed and unsprayed plots (See Table 6.). In the sprayed plots there was very little difference in the yields of the 2, 4 and 8-inch spacings. As in the Bountiful series the 2-inch plots produced a low percentage of uninjured pods. The 6-inch unsprayed block yielded very little more than the 4-inch plot, and the 2- and 8-inch plots yielded smaller amounts. The unsprayed 4-inch plots showed a slightly greater yield than the sprayed plots of the same spacing, but this was probably due to the larger number of plants. The same condition has been noted above in the case of the 8-inch plots of Bountiful. The percentage of uninjured beans decreased with increased spacing and in general was much higher than in the case of Bountiful beans. Here again the number of pods per plant, yield per plant and size of pods increased with increased spacing. The quality of the pods was better on the 4, 6 and 8-inch plots than on the 2-inch plots.

The accompanying plates show the appearance of samples of pods from the 2-inch and 8-inch plots. As these photographs indicate, the pods from the 2-inch plots were not marketable unless they were sorted. There was little difference in appearance between pods from the 4, 6 and 8-inch sprayed plots. The crop from the 6- and 8-inch unsprayed plots was marketable as picked from the vines, but pods from the 2- and 4-inch unsprayed plots were very badly damaged by larval feeding, and were not salable.

Discussion. It is evident that the Mexican bean beetle preferred closely planted beans for oviposition. This preference resulted in severe injury to unsprayed beans planted only 2 inches apart. In spite of very careful hand spraying, this heavy infestation was not sufficiently reduced to protect the pods from feeding injury. It is true that in this study the beetles had a choice of situations for oviposition within a small area, and therefore no statement as to results under commercial conditions can be made. However, the fact that careful hand spraying did not adequately protect beans planted 2 inches apart is sufficient justification for a recommendation to plant beans at least 4 inches apart in areas where the Mexican bean beetle is a serious pest. Under more favorable soil and weather conditions closely planted plants would probably show an increased yield over wider spacings, but there should be no marked differences in relation to bean beetle control as compared with the results obtained in this experiment.

Since this study covers only one growing season, it is hardly justifiable to draw definite conclusions except for the inadvisability of planting beans as close as two inches as mentioned above. The writers expect to

continue investigations into the relation of cultural practices to bean beetle injury and control for several seasons.

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INSECTICIDES FOR THE CONTROL OF THE MEXICAN BEAN BEETLE

By Neale F. Howard, L. W. Brannon, and H. C. Mason, *Bureau of Entomology, United States Department of Agriculture*

Abstract

Field tests over a period of three years indicate that potassium hexafluoaluminate and synthetic cryolite are satisfactory for the control of the Mexican bean beetle (*Epilachna corrupta* Muls.) when used as sprays at the rate of 3 pounds to 50 gallons of water. Barium fluosilicate (80 per cent) must be used at the rate of 5 pounds to 50 gallons of water to give satisfactory control, and is considered too expensive to be recommended. These compounds have not given satisfactory control when used as dusts. There appears to be no advantage in changing current recommendations for the use of magnesium arsenate except that the dosage should be increased from 1 pound to 2 pounds to 50 gallons of water where the infestation is heavy. If fluorine compounds are used, the problem of poisonous residues on green beans is not avoided, and green beans should not be sprayed with any of the above compounds after the pods have set.

The problem of the control of the Mexican bean beetle (*Epilachna corrupta* Muls.) by the use of insecticides has been extensively investigated since the discovery of that insect in the eastern part of the United States in 1920. At the outset it was necessary to find an insecticide which would kill the insect but would not injure the tender foliage of the bean plant. Effort was rewarded in the discovery that magnesium arsenate fulfilled the requirements, but that material is not useful as a general insecticide, and is, therefore, not widely distributed, owing to the fact that it is not in demand in large quantities and for general use.

Since the advent of fluorine compounds[1] many hundreds of tests have

[1]Marcovitch, S., Bul. 131, Tenn. Agr. Exp. Sta. 1924.

been conducted. The first fluorine compounds recommended, namely sodium fluosilicate and so-called calcium fluosilicate compound, were not entirely satisfactory. The former injured bean foliage under certain conditions and the latter was lacking in toxicity. Promising results, however, were obtained with other compounds.[2] Later, synthetic cryolite and barium fluosilicate became commercially available and potassium hexafluoaluminate became a commercial possibility. These compounds have been tested for three years and the present status of the investigations is here reported. Also, much progress has been made in the preparation of derris extract, pyrethrum extract, and rotenone, and tests with these compounds are reported.

Fluorine is poisonous to animals and human beings and compounds containing this element must be considered in the same class as those containing arsenic.

During the investigations reported here, many hundreds of applications of various compounds have been made but space will permit only a few general conclusions. Fifty experiments, involving 1,697 plots and over 5,000 applications, were performed during the three seasons.

The work has been conducted at Athens and Columbus, Ohio, and at Norfolk, Va., the work at the latter place being carried on cooperatively with the Virginia Truck Experiment Station. Yield records referred to were obtained at Norfolk, Va., usually under very light or no infestations of the Mexican bean beetle.

Usually a period of three years is sufficient for judging rather definitely the worth of an insect-control measure, but the years 1930, 1931, and 1932 were not normal years. The growing seasons were dry and hot, especially during 1930. The summaries presented here are rather in the nature of progress reports than final conclusions. The trials of rotenone dust cover only two seasons on a few plots, and those with derris extract cover only one season's results on a few plots.

CRYOLITE—SYNTHETIC. The use of this commercial product resulted in increased yields in the great majority of the experiments and appears to be beneficial to the bean plant. At Norfolk it gave excellent results at both 1 pound to 50 and 2 pounds to 50 gallons of water, under conditions of light or medium infestation. It is apparently compatible with Bordeaux mixture.

In Ohio under conditions of heavier infestation only fair control was obtained at 1 pound to 50 gallons and it was not so effective as magnesium arsenate at 1 pound to 50 gallons. At 2 pounds to 50 gallons of

[2]Marcovitch, S., Buls. 134, 140, Tenn. Agr. Exp. Sta. 1926, 1929.
Howard, N. F., Jr. Ec. Ent. Vol. 21, pp. 178–182, Feb. 1928.

water it gave the same degree of control as magnesium arsenate used at the same rate, in most instances, but not so good control under conditions of very heavy infestation. When the dosage was increased to 3 pounds to 50 gallons, control was improved and slightly better results were sometimes obtained than with magnesium arsenate at 2 pounds to 50 gallons, but no better under conditions of very heavy infestation. Increasing the dosage to 4 pounds to 50 gallons did not improve the control.

The material is not very satisfactory for use as a dust and it does not give very satisfactory control undiluted or diluted with equal parts of infusorial earth or lime, but is considerably superior to 80 per cent barium fluosilicate. Its use as a dust is not recommended at present.

In some of the experiments the material did not protect the foliage as long as magnesium arsenate, and it is possible that it may not prove so satisfactory during wet seasons Each of the three years during which this work was carried on was a relatively dry year and the infestations of the bean beetle where the work was carried on were not so heavy as some which have been experienced in the past.

At present prices there would be no advantage in substituting this material for magnesium arsenate, but it is apparently less injurious to bean foliage. Should its use as an insecticide and its distribution become general, it may prove to be a welcome substitute for magnesium arsenate

The fluorine compounds may improve as more experience is gained in their manufacture. Their use does not mitigate the danger of poisonous residues on edible truck crops, and when they are used it is not recommended that green beans be sprayed after the pods have set.

POTASSIUM HEXAFLUOALUMINATE. At Norfolk, Va , potassium hexafluoaluminate gave excellent control at 2 pounds and 1 pound to 50 gallons of water. Increased yields were obtained in the majority of instances even when the bean beetle was not a factor in the experiments.

In Ohio it was found that 1 pound to 50 gallons of water was insufficient to afford good control. When used at 2 pounds to 50 gallons it gave about the same degree of control as cryolite and magnesium arsenate at the same rates. At 3 pounds to 50 gallons of water it was slightly superior to cryolite at the same rate and to magnesium arsenate at 2 pounds to 50 gallons. Increasing the dosage to 4 pounds to 50 gallons did not improve control.

As in the case of cryolite, while this material may be substituted for magnesium arsenate, there seems to be no advantage in changing the recommendation at this time.

The material used had poor dusting qualities.

Barium Fluosilicate (80 Per Cent). At Norfolk, Va., this commercial product gave good results at 1 pound and 2 pounds to 50 gallons of water and very good results at 4 pounds to 50. The increase in yields was greater in some experiments than the reduction in yields in others, and the material is not considered injurious to the bean plant.

In Ohio almost no control was obtained in many instances when the material was used at 1 pound and at 2 pounds to 50 gallons of water. Even at 3 pounds and 4 pounds to 50 gallons of water unsatisfactory control was obtained and it was inferior to cryolite and magnesium arsenate at 2 to 50. At 5 pounds to 50 gallons of water it rendered about the same degree of control as cryolite and potassium hexafluoaluminate at 3 pounds to 50 gallons, and as magnesium arsenate at the latter rate.

Used as a dust, undiluted or diluted with infusorial earth or lime, very unsatisfactory control was obtained and almost no control in some cases when used with equal parts of a carrier.

Visible foliage injury has been noted in a few instances when used at 4 pounds to 50 gallons, but in no case has it proved serious.

At present costs and in view of the heavy dosage required. it is not recommended for the control of the Mexican bean beetle.

Barium Fluosilicate (98 Per Cent). At Norfolk, Va., increased yields resulted in the majority of the experiments when 98 per cent barium fluosilicate was used, even though insects were not a factor. No appreciable difference in results between this material and the 80 per cent material could be noted when they were used as sprays, although slightly better results were obtained by both. Control was unsatisfactory at 1 and 2 pounds to 50 gallons.

It has poor dusting qualities.

Magnesium Arsenate. During 1932 magnesium arsenate at 1 pound to 50 gallons of water gave good control in most instances but only fair results at other times. Increased yields resulted in the majority of the experiments. When the dosage was increased to 2 pounds to 50 gallons, better control was obtained but still it did not come up to the standard of former years. Chemical analyses gave no indication of an explanation.

Under conditions of very heavy infestation there have been indications that this arsenical protects the foliage for a longer period of time than do the fluorine compounds, and that 2 pounds of this material is equal to 3 pounds of cryolite or potassium hexafluoaluminate or 5 pounds of 80 per cent barium fluosilicate. Up to 1932 this material

gave as good or better results at 1 pound to 50 gallons as the fluorine compounds at twice the dosage.

Under certain conditions foliage injury may result from its use but at no time has this been serious, and it is usually unnoticed.

This material is not very satisfactory for use as a dust. In fact, there is no effective dust at a reasonable cost which does not injure bean foliage in the Eastern States.

With present knowledge, it is deemed advisable to continue recommendations of the use of this material at 1 pound to 50 gallons except in cases of heavy, infestation, when the dosage should be increased to 2 pounds to 50 gallons.

CALCIUM ARSENATE. Calcium arsenate has not been recommended without reservation by the Bureau of Entomology for use in the Eastern States for several years, owing to the variability of results obtained with different brands as to its injuriousness to the bean plant. A rather intensive study indicated no chemical means of determining how a given sample would affect a bean plant, and no specifications could be made which would avoid injury. The material is effective against the beetle both as a spray and as a dust

Certain brands may be used as dusts when diluted with 7 parts of hydrated lime, or with 1 part of dusting sulphur and 4 parts of lime. As mentioned below, monohydrated copper-calcium arsenate-lime dusts are also cautiously recommended

BORDEAUX MIXTURE. Bordeaux mixture (4–6–50) as a rule causes reductions in yields when used alone or in combination with arsenicals or fluorine compounds, in the absence of insect pests, especially when used on lima beans. However, plant injury from calcium arsenate is usually reduced, especially when a weaker mixture (2–6–50 or 3–6–50) is used. Unless protection is desired against leaf hoppers or plant diseases, its use is not unqualifiedly recommended. In combination with calcium arsenate or magnesium arsenate, excellent control of the bean beetle is obtained. The grade of calcium arsenate used is one of the determining factors in plant injury. Visible foliage injury, while sometimes apparently severe, is often outgrown without deleterious effects.

DERRIS EXTRACT. A commercial extract of derris root, containing 5 grams of rotenone per 100 cc. and other extractives, gave satisfactory control at Norfolk, Va., under conditions of light to medium infestation, when used at dilutions of 1 to 250, 1 to 500, 1 to 800, and 1 to 1,000.

Under conditions of medium to heavy infestation in Ohio during 1932, at 1 to 250 and 1 to 400 it gave results equal to or better than magnesium arsenate at 2 pounds to 50 gallons and cryolite at 2 pounds

to 50 gallons of water, and better than a well-known pyrethrum extract at 1 to 400. Only one season's results are available, and further trials should be made before it can be recommended.

It appears to be superior to pyrethrum extract and equal to a combination of the two.

It also appears to be far superior to pure rotenone.

High cost is a prohibitive factor, but since it is probably relatively harmless to man and animals it should be valuable for use, when necessary, on high-priced crops, after pods have set.

STICKERS. On a relatively short-lived plant like the bean the value of the addition of stickers is doubtful. No improvement in control was noted when casein-lime mixture or potash fish-oil soap was used with magnesium arsenate and with the fluorine compounds

MONOHYDRATED COPPER-CALCIUM ARSENATE-LIME The use of monohydrated copper-calcium arsenate-lime dust, both 15–15–70 and 20–20–60, resulted in reduced yields in the majority of instances, in the absence of insect pests. It is used in some localities quite extensively and with probably as good results as any dust mixture which is recommended, but the quality of control obtained is far inferior to that obtained with sprays. When well mixed and when it contains a grade of calcium arsenate which is not very injurious to bean foliage, it is probably as satisfactory as any dust which is commercially produced and widely distributed

ROTENONE DUST. In 1932 a commercial dust containing 0.275 per cent of rotenone gave fair results. Its price at present probably makes this mixture too expensive for general use. As mentioned above, dusting has not proved satisfactory in the Eastern States and dusts are not recommended for good control. However, they are much used because of the ease and speed of application.

In 1931 a commercial dust containing 0.15 per cent of rotenone was ineffective.

PYRETHRUM DUSTS. A commercial dust comprising ground flowers and an inert material, as well as one comprising an inert material impregnated with pyrethrum extract, gave poor results The impregnated dust gave poorer results than the ground flowers

DR. T. J HEADLEE: I have heard during the meetings that tests were put on this summer with magnesium arsenate which resulted very unsatisfactorily, the performance of the magnesium this year not being anywhere equal as in the previous years.

DR. HOWARD: The discussion of magnesium arsenate happened to

be left out. That was true. We have not been able to explain it. The chemical analysis made by the Bureau of Chemistry would not indicate any reason for that experience. However, by increasing the dosage, the material gave control about equal to the other materials used.

DR. FRIEND: I might add in our experiments on the Mexican bean beetle we have been using three pounds of magnesium arsenate instead of two, but did not notice any definite increase in the results obtained. We obtained better results with the magnesium arsenate spray than with any other insecticides. There may be some local differences in the beans or whatever it is, aside from the magnesium arsenate itself.

DR. HOWARD: You used magnesium, three pounds in fifty gallons. I believe in that concentration it is equal or superior to any materials we have tested. Our recommendation in the past has been one pound to fifty gallons.

REPORT ON THE CONTROL OF THE HARLEQUIN BUG, *MURGANTIA HISTRIONICA* HAHN, WITH NOTES ON THE SEVERITY OF AN OUTBREAK OF THIS INSECT IN 1932

By HARRY G. WALKER and LAUREN D. ANDERSON, *Virginia Truck Experiment Station, Norfolk, Va*

ABSTRACT

The severe outbreak of the Harlequin bug, *Murgantia histrionica* Hahn, during the summer of 1932 in the Norfolk truck crop area was due in part to the mild winter of 1931–32 and to the abundance of preferred host plants in abandoned fields and in seed kale fields. The best control of this pest was obtained with sprays in which rotenone was the active ingredient in combination with a one per cent soap solution. In general, nicotine, Pyrethrum, and oil emulsion sprays were not effective for use against this insect, except at very strong concentrations.

Swallows were observed feeding on the adult insects. The egg parasite, *Ooencyrtus johnsoni* (How.), was found to parasitize from 35 to 55 per cent of all the Harlequin bug eggs collected during August and September.

The mild winter of 1931–32 and the fact that a large number of fields containing cruciferous crops were either abandoned or left standing for seed furnished ideal conditions for the development of a very large population of Harlequin bugs in the vicinity of Norfolk, Va. However, trouble began about the middle of August when dry weather and the feeding of large numbers of these insects, largely second, third and fourth instar nymphs, caused the host plants to dry up and die. The nymphs began migrating out of these fields in search of new food, like

chinch bugs moving from a wheat to a corn field, seriously damaging early fall cabbage and completely killing fields of young kale. They also collected and fed on a large number of other than cruciferous plants, including corn, tomatoes, soy beans, cantaloupes, watermelons, privet hedge, and a large number of different kinds of weeds. Over 5,100 nymphs were collected on one corn plant and fully as many more fell to the ground and were not counted. This corn plant was at least a quarter of a mile from the source of the infestation.

Deep furrows plowed around some of the fields were not successful in stopping the migration. The nymphs marched over creosote barriers without even appearing to notice them. Successful control of the migrating nymphs was obtained, however, by plowing under and destroying their breeding grounds and all seriously injured fields or parts of fields of young cruciferous crops. The remaining nymphs were then either hand picked or sprayed with a two per cent soap solution as recommended by Fulton [1] When thoroughly applied, the soap solution gave very good results.

Later, a severe outbreak of the adults occurred The host plants in some of the abandoned or neglected fields remained green longer than in others. In these fields large numbers of the nymphs matured before their host plants died. Millions of these adults then flew into surrounding fields of kale, collards, cabbage, Chinese cabbage, broccoli, rutabagas, turnips, mustard, corn, tomatoes, and soy beans, and others collected on trees, shrubs, and grasses, and weeds of various kinds. Many of the jimson weeds, pigweeds, and ragweeds were so heavily loaded with these insects in the infested fields that the plants bent over with their weight, the under sides of the leaves often being completely covered with them. One man collected over five gallons of these bugs from tall weeds and soy beans in a kale field in less than five hours. The adults were flying over several young kale fields examined on different warm days in such great numbers that they appeared like a swarm of bees in flight. These adults completely destroyed a large number of fields of kale, collards, and cabbage, and seriously injured many others. One 40 acre field of young, vigorously growing kale was entirely killed out within three weeks after the adults began flying into it from an abandoned field. These insects were observed flying across a small lake in the face of a strong wind and landing in a field of collards on the other side, completely destroying it in a few days.

The adults proved to be much more difficult to control than the

[1]Fulton, B. B 1930. The relation of evaporation to the killing efficiency of soap solutions on the Harlequin bug and other insects. Jour. Econ. Ent. 23 (3): 625–630.

nymphs. The two per cent soap solution failed to give satisfactory control except under ideal conditions of low temperature, high humidity, and no wind. These conditions seldom occurred. Consequently, a large series of contact sprays and wetting agents were tested at various concentrations and combinations for the control of this resistant sucking insect. The following were used: various Pyrethrum sprays such as Red Arrow, Evergreen, M-P Plant Spray, Penethrum, Guardian, and Black Arrow (a Pyrethrum dust), Black Leaf 40 alone and in combination with Penetrol and several different kinds of soap, a five per cent nicotine dust (freshly made), nicotine tannate, carbon disulphide emulsion, paradichlorobenzine emulsion, miscible oil emulsion, Bordeaux oil emulsion, kerosene emulsion, various soaps such as Red A, C. P. O., Linso, and a cocoanut oil soap (all liquid soaps), Ivory soap and Ivory soap powder, P. and G. soap and a home made soap, and several Derris products, including four dusts, Ku-ba-tox, Sentone, Derrax, and a Powdered Air Float Derris Root alone and in combination with an inert carrier, and three sprays, Noxon Plant Spray, Serrid, and Super Agricultural Spray.

All of these materials were tested in the insectary and all that gave any promise of being effective were then tested in the field. The insectary tests were made either by thoroughly dusting the insects with a small hand duster or by spraying them with a small hand sprayer and then placing them in screen cages 12 inches high by 5½ inches in diameter. Each treatment was run in triplicate. Field tests were made with rotary hand dusters and with four gallon hand sprayers and with a power sprayer. Three checks were included in each experiment. Counts were made of the number of dead, active and morbid insects at 24 and 48 hours after treatment.

Typical examples of the results obtained for the control of the adults with different Pyrethrum sprays and with Nicotrol, Penetrol and Ivory soap are given in Table 1. Evergreen was used with a 1/200 solution of Red A soap. It may be noted that a one per cent solution of Ivory soap gave the best kills, followed by M-P plant spray. The fact that higher kills were obtained with the M-P plant spray than with any of the other Pyrethrum sprays was probably due to its greater soap content. Even though the M-P plant spray and the Ivory soap did give fairly high kills in the insectary, they failed to give even 50 per cent control in the field. Nicotrol and Penetrol gave practically no control.

In other tests, Black Leaf 40, either alone or in combination with different soaps, appeared to have little if any effect on these insects. They kicked very violently for a time after being dusted with a freshly

mixed five per cent nicotine dust, but all recovered and appeared to be feeding normally 24 hours after being treated. Nicotine tannate gave very poor results.

TABLE 1. A TYPICAL EXAMPLE OF INSECTARY TESTS WITH DIFFERENT PYRETHRUM SPRAYS AS COMPARED TO NICOTROL, PENETROL, AND IVORY SOAP FOR THE CONTROL OF THE HARLEQUIN BUG

Material	Dilution	No. of insects	Total for three tests: No. dead and morbid	Total for three tests: Per cent dead and morbid
Red Arrow:	1/50	89	36	40.4
	1/100	95	23	24.2
	1/200	84	7	8.3
Evergreen:	1/50	90	25	27.8
	1/100	93	6	6.5
	1/200	91	7	7.7
M-P Plant Spray:	1/50	91	81	89.0
	1/100	87	30	34.5
	1/200	91	19	21.0
Guardian:	1/50	93	41	44.0
	1/100	91	54	59.3
Penethrum:	1/50	89	28	[illegible]
	1/100	91	6	6.
	1/200	92	9	9.8
Nicotrol:	1/50	92	3	3.3
	1/100	88	1	1.1
Penetrol:	1/50	87	0	0.0
	1/100	89	0	0.0
Ivory Soap:	1%*	89	82	92.1
	½%*	88	51	58.2
	¼%*	90	23	25.6
Check....		91	5	5.5

*Per cent of spray solution by weight.

None of the emulsions gave satisfactory control of the adults. However, the ten per cent kerosene emulsion killed a large per cent of the nymphs, but there is considerable danger of spray injury resulting from the use of this material unless it is properly made and applied.

The two per cent soap solutions gave fairly good control when the Harlequin bugs were thoroughly wetted under ideal conditions of high humidity, moderately low temperature, and a very low rate of evaporation. Weight for weight, Ivory soap gave much better results than P. & G. soap, but when they were used on a dry weight basis, they were about equally effective. In fact, all of the soaps tested appeared to give about equally good results when used at the rate of a two per cent water free soap. The use of soaps for the control of this insect is limited

in the Norfolk area by the small amount of time available when the weather conditions are right for spraying.

The best results were obtained with materials in which rotenone was the active ingredient. The most extensive tests were carried on with a product known as Serrid, a derris extract with a rotenone content of five grams per 100 cc.[2] Table 2 gives the results of several typical field and insectary tests with this material, alone and in combination with powdered Ivory soap. It may be noted that a one-fourth per cent soap solution in combination with Serrid gave nearly as high kills in the insectary as a two per cent soap solution in combination with Serrid in the field. Also, Serrid alone and the soap alone even at weaker dilutions gave higher kills in the insectary than in the field. As shown, the addition of soap to the Serrid greatly increased its effectiveness. However, the Serrid and soap combination should be used as soon as it is mixed as Turner[3] and others have shown that rotenone deteriorates rapidly in the presence of soap Practical field control of adult Harlequin bugs on young kale has been obtained with one part of Serrid to 200 parts of a one per cent powdered Ivory soap solution, applied under 150 to 200 pounds pressure However, it should be emphasized that the insects must be thoroughly covered with the spray material in order to secure satisfactory control [4] In view of the harmful effect of the soap on rotenone, it may be possible to develop a better contact agent than soap for this purpose

In experimental tests, Noxon Plant Spray was about one-half as toxic as the Serrid and soap spray. Ku-ba-tox, a rotenone dust, did not give satisfactory control, which was possibly due to its low rotenone content.

Preliminary tests with Super Agricultural Spray, a Derris product, at the rate of one part to 200 parts of water, and with Powdered Air Float Derris Root with a four per cent rotenone content used at the rate of one part to three and four parts of an inert carrier, known as Inert C, has given satisfactory control both in the insectary and in the field. However, these tests were so limited in number that further experiments must be conducted under varied conditions before their use can be generally recommended. Sentone and Derrax, two rotenone dusts, were

[2]Serrid, Super Agricultural Spray and Powdered Air Float Derris Root were furnished by Derris, Inc , 79 Wall Street, New York City.

[3]Turner, Neely 1932. Notes on Rotenone as an insecticide. Jour. Econ. Ent. 25 (6): 1228-1237.

[4]Mr. L. W. Brannon of the Bureau of Entomology of the United States Department of Agriculture, located at the Virginia Truck Experiment Station, has also obtained very good results with the Serrid and soap spray.

Table 2. Comparison of Field and Insectary Tests with Serrid and Soap for the Control of Harlequin Bugs

Field Test

Material	Dilution	Test No. 1 No. insects	Test No. 1 % dead and morbid	Test No. 2 No. insects	Test No. 2 % dead and morbid
Powdered Ivory soap:	½%	54	0		
	1 %	35	40	79	29
	2 %	20	75	81	43
	3 %			88	65
½% Powdered Ivory Soap+Serrid:	1/200	54	89		
	1/400	64	89		
	1/800	66	57		
1% Powdered Ivory Soap+Serrid:	1/200	50	98	67	91
	1/300			69	68
	1/400	46	74	75	48
	1/800	67	34		
2% Powdered Ivory Soap+Serrid:	1/200	42	98	76	91
	1/300			78	92
	1/400	25	80	87	93
	1/800	31	84		
Serrid:	1/200	49	94	62	26
	1/300			61	21
	1/400	43	16	61	7
	1/800	40	17		
Check:		65	3	65	0

Insectary Test

Material	Dilution	Test No. 1 No. insects	Test No. 1 % dead and morbid	Test No. 2 No. insects	Test No. 2 % dead and morbid
Powdered Ivory soap:	¼%	89	12	86	46
¼% Powdered Ivory Soap+Serrid:	1/200	88	98	88	91
	1/400	89	79	89	61
	1/800	91	59	91	24
	1/1600	90	45	88	14
Serrid	1/200	88	70	89	72
	1/400	89	55	91	35
	1/800	90	22	90	8
	1/1600	91	8	92	0
Check:		90	8	91	1

not quite as effective in insectary tests as was the Powdered Air Float Derris Root dust.

Burial experiments were also conducted, in which less than 40 per cent of the nymphs or adults were able to crawl out when covered with one-half inch of loose soil, less than ten per cent were able to crawl out when covered with one inch, and less than five per cent were able to crawl out when covered with two or more inches of loose soil. However, some of the adults were found to remain alive when buried in the ground with young kale plants for a period of at least 17 days.

Swallows were observed feeding on the adult insects as they were flying from one field to the other. One of these birds was shot and several Harlequin bugs were found in its gizzard.

The hymenopterous egg parasite, *Ooencyrtus johnsoni* (How.) was found to parasitize from 35 to 55 per cent of all Harlequin bug eggs collected during August and September As many as 35 parasites were reared from twelve eggs This parasite went through its complete life cycle in from 16 to 17 days. It was also reared from lady bird beetle eggs.

MR. WALKER: We obtain our best results with serrid and soap combination. However, the super agricultural spray and derris root may prove effective if conducted on a large scale. The weather did not permit us to complete our tests with those materials. Preventive measures are best where they can be applied

OBSERVATIONS ON CULTURAL PRACTICES FOR THE CONTROL OF THE POTATO TUBER WORM, *PHTHORIMAEA OPERCULELLA* ZELL.

By GEORGE S. LANGFORD, *Specialist in Insect Control, University of Maryland, College Park, Md.*

ABSTRACT

A summary of experimental tests on hilling or ridging potatoes for the control of the potato tuber worms. Ridged culture is effective in reducing tuber injury if applied properly and timely.

Occasionally, especially during dry years, the potato tuber worm occurs in sufficient numbers in Worcester and Somerset counties on the second crop of potatoes to demand effective control measures. Cultural practices for control of this insect have been investigated along with other researches on this insect.

Graf[1] in 1917 showed that in addition to certain sanitary and precautionary measures, deep planting and ridging, or hill culture, was effective in reducing the infestation in potato tubers growing under California conditions. Poos and Peters[2] in their research showed that tubers growing from 1 to 2 inches below the soil were free from infestation on the Eastern Shore of Virginia.

Deep planting in combination with ridging is effective in reducing tuber injury under conditions encountered on the Eastern Shore of Maryland. This was demonstrated by practical field work in Worcester and Somerset counties supplemented by laboratory experiments at College Park.

In 1930 a comparative study of ridged and unridged fields in Worcester and Somerset Counties showed that the average infestation for unridged fields was 18.27% infested tubers while that for the ridged fields was 5.5%. The infestation in ridged fields varied from 0.3% to 16.6% depending upon one or more of the following factors: the thoroughness of and the care given to the operation, height of the ridge, time elapsing between planting and ridging, soil type and the amount of rain falling after ridging. The infestations in unridged fields varied from 10.1% to 34.4%.

The results obtained in laboratory tests at College Park with potatoes planted in greenhouses were much more outstanding. All tests were run in duplicate, and were ridged by covering the soil level in which the potatoes were growing with 5 to 6 inches of soil by throwing the soil from the center of the rows to and around the potatoes. Potatoes planted 2 inches deep and not ridged averaged 46.2% infested tubers. Ridged potatoes planted at the same depth were free from infestation. Potatoes planted four inches deep averaged 4.8% infested tubers. The ridged plots were free from infestation. Potatoes planted six and eight inches deep had an average infestation of 5.1% and 8.1% infested tubers respectively. The ridged plots in both cases were free from infestation.

Early in the season of this year conditions were such that an outbreak of the potato tuber moth was anticipated. Field experiments were arranged to further test the effectiveness of ridging. Probably due to adverse weather conditions, the outbreak failed to materialize. However, a careful survey of fields in Worcester county revealed that practically 100% of all exposed tubers were infested. The average infestation in the experimental plots on digging was 0.9% infested tubers. The minimum infestation in any of the plots was 0.6% and the maxi-

[1]U. S. Dept. of Agr. Bul. 427.
[2]Va. Truck Exp. Sta. Bul. 61.

mum was 1.2% infested tubers. In no instance was any infestation found in the ridged plots.

The time elapsing between the planting date and the time of ridging appears to have a bearing on the effectiveness of ridging for control. In 1930 observations in nine fields showed that fields ridged in from 40 to 50 days after planting had an infestation that varied from 0.3% to 1.5% infested tubers, while fields ridged, 60 to 75 days after planting had an infestation varying from 6.4% to 12.8% infested tubers. This phase of the study deserves further attention.

General field observations indicate soil types affect the efficiency of the ridging operation. Tubers harvested from potato fields planted in soils that crack badly or in very light soils in which heavy rains wash the ridge down badly are usually more severely infested than those from soils that do not crack or wash easily. One laboratory test at College Park on potatoes grown in the greenhouse indicated that soil kept wet during the period of tuber formation and growth tends to reduce the number of tubers infested. Potatoes planted two inches deep that were grown in soil that was kept wet during the above period averaged 5% infested tubers at harvest, while those grown in comparatively dry soil averaged 60% infested tubers.

OBSERVATIONS ON THE TOMATO PIN WORM (*GNORIMOSCHEMA LYCOPERSICELLA* BUSCK) AND THE EGG PLANT LEAF MINER (*G. GLOCHINELLA* ZELLER) IN PENNSYLVANIA[1]

By C. A THOMAS, *Pennsylvania State College*

ABSTRACT

Gnorimoschema lycopersicella Busck, found for the first time in Pennsylvania in 1931, has apparently been eradicated there by certain greenhouse practices. A description is given of the various stages of this insect and of the injury caused by it. Notes are also given on the occurrence of the Eggplant Leaf Miner, *G. glochinella* Zeller, in the same area, and on several parasites reared from its larvae.

As noted in the Journal for Feb. 1932, p. 137, the writer, in September, 1931, found a small lepidopterous larva causing considerable injury to tomatoes in a commercial greenhouse near Coatesville, Pa. Adults, reared from these larvae, were identified by Mr. Busck of the National Museum as the Tomato Pin Worm, *Gnorimoschema lycopersicella* Busck. Previously it had been listed as occurring only in Mexico, California and Hawaii, and was described by Busck from Hawaiian

[1]Family Gelechiidae.

specimens in 1928 (1928). For a number of years it had been confused with closely related *G. glochinella* Zeller, and it was only when Busck noted the differences in the genitalia that the two species were definitely separated. In the late spring of 1932, Watson found *G. lycopersicella* causing trouble to tomato growers near Bradenton, Florida (Insect Pest Survey Bulletin, XII, No. 6, p. 271). The above, with the present record, constitute the only present known distribution of this insect.

In California, the Pin Worm has done much damage to tomatoes, as is evidenced by reports of forty per cent destruction of the crop in San Diego county in 1930. Campbell and Elmore (1931) stated that many fields were abandoned after unsuccessful attempts to market fruit from them.

This insect apparently first appeared in this Pennsylvania greenhouse in the winter of 1929–1930. It possibly was brought to the farm with some green tomatoes which the owner, a commission merchant, imported from California during the previous summer and stored in his cellar. That winter so few of the plants were injured that the grower paid little attention to them, but during the winter and early spring of 1930–1931, it became very abundant in his greenhouse, causing injury which he estimated at about fifty per cent of the crop. It also spread into an outdoor tomato planting, during the spring and early summer of 1931, causing such damage that only three baskets of marketable tomatoes were obtained from an acre. In addition to tomatoes, it also infested the Horse Nettle, *Solanum carolinense* L., which is apparently a new food plant for this insect. A large percentage of these weeds on this farm were found to be infested. Only one occurrence was found outside this farm; this was in a few tomato plants in a private garden about one mile distant. None were found in other greenhouses in that vicinity, but it was feared that they might spread via the Horse Nettles scattered over that countryside.

INJURY. The injuries caused by this insect are different from any other caused to tomato plants in this vicinity. When larvae hatch from eggs on the leaves, they soon mine into the leaf, generally at a distance from the edge, and make an irregular blotch mine. As it grows, however, it may leave this mine and then draws together two places in the leaf to form a fold held together by a loose platform of silk strands. The larva then rests on the inside of the platform and feeds on the leaf tissues below it, frequently working upside down while feeding. Several folds may thus be formed on a leaf, or the larva may move to another leaf to feed. This species does not form the heavy dry, brown, leaf-edge cell characteristic of *G. glochinella* Zeller.

The second type of injury is the boring up through the stem of the flower buds, so that these buds may dry up and fall off. The leaf petioles and the main stem are also occasionally mined. The most important injury, however, and the one which has given this insect its name of Pin Worm, is that done to tomato fruit. Here the small larvae bore into the tomato, generally in the stem end, and several holes may be made extending for some distance into the tissues. These holes may be lightly webbed, and are usually not more than a couple of millimeters in diameter, but several such holes may cause the tomato to drop fifty per cent or more in market value. Injury usually begins while the fruit is still green or beginning to color.

DESCRIPTION OF STAGES. The eggs of this moth are very small, white, and nearly round, and are laid on the leaves, on the stems and flower buds, or on the fruit near the stem end.

The tiny larvae are light-colored, with a dark head and cervical plate, but without any definite markings or color pattern on the thoracic or abdominal segments. As the larva grows its ground color becomes a light greenish or grayish green color, which increases in brightness as the larva becomes mature. Over this lighter color a definite pattern appears upon the half-grown larva as follows: The eyes are dark, with a heavy black or dark gray line extending through them to near the posterior part of the head. On the thorax, the cervical plate is light colored, with a short, broken line across the center of the disk, and a wide dark gray or black line extending from near each front corner, along the sides to near the rear center. The other thoracic segments, and the abdominal segments, are marked on the dorsum with a series of spectacle-shaped, purplish-black markings, which are characteristic of this species, and serve to distinguish the full grown larva from the practically unmarked larva of the closely related *G. glochinella*. Another row of small patches of the same color is found along the spiracles, while on the underside of the abdominal segments is found a row of small crescent-shaped spots or lines. Most of these abdominal and thoracic markings disappear in alcoholic specimens, but those on the head and cervical plate may persist. The full-grown larva measures from 5 to 6.5 mm. in length.

Pupation may occur either in the fold in the leaf, or the larva may go down into the soil for a short distance. Only a very flimsy cocoon is spun, within which pupation occurs. The pupa, which is about 4 to 4.5 mm. long and 1 to 1.2 wide, is at first varicolored with brown, green, blue, etc., but soon becomes chestnut brown to yellowish brown. As with *G. glochinella*, a circular row of light hooked spines adorns the anal segment. However, most of the pupae of *G. lycopersicella* examined by the writer lack the short, stout hooked elevation found on the dorsum of the anal segment of *G. glochinella*.

The adult closely resembles the adult of *glochinella*, in its external morphology, but the genitalia are clearly distinct in both male and female of *lycopersicella* from those of the corresponding sex of *glochin-*

ella. Full original description of *lycopersicella*, and detailed descriptions of the genitalia of these two species, with figures, are found in Busck's paper in the Proceedings of the Hawaiian Ent. Society, Vol. VII, No. 1,

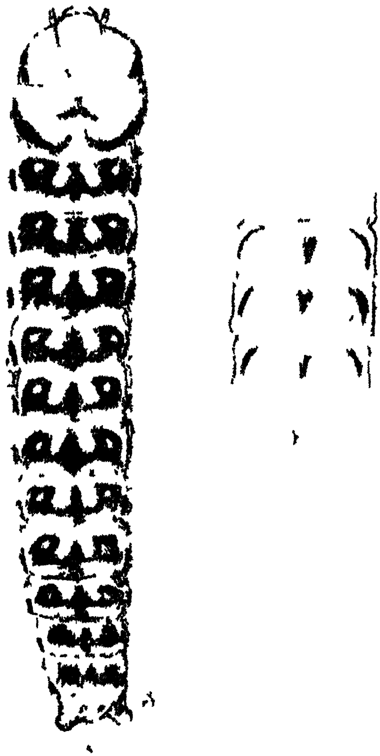

FIG. 11.—Tomato Pin Worm, *Gnorimoschema lycopersicella* Busck.
A—Dorsal, view of larva, and B—ventral view of several abdominal segments, to show markings. (Original.)

p. 171, June, 1928. It may be mentioned that the easiest distinction between the two species is shown in the harpes. In *lycopersicella* the harpes are long, slender, sinuate, enlarged and forked at the tip; in *glochinella* the harpes are stouter, less sinuate, and not forked, but lack the extra tooth.

In the infested greenhouse where these insects were found in Pennsyl-

vania the moths were sometimes quite common flying among the tomato plants when disturbed. They were somewhat attracted to light-kerosene traps.

NATURAL ENEMIES. Campbell and Elmore (1931) do not mention any parasites of *G. lycopersicella* Busck in California. Swezey (1928) stated that about fifty per cent of larvae collected in Hawaii were parasitized by the Ichneumonid, *Angitia blackburni* (Cam.) The writer has found no parasites of this species during his short experience with it in Pennsylvania.

CONTROL. Campbell and Elmore (1931) reported that no satisfactory control measure had been established. Morrill (1926) reported partial control by dusting with calcium arsenate.

The situation in the greenhouse at Coatesville was handled as follows: After consultation with the writer, the grower decided not to plant any first crop of tomatoes during the fall of 1931, but to leave the greenhouse empty and open until the spring crop was planted the following February.

The house was thoroughly cleaned out in November, 1931, and all straggling tomato plants (most of which were heavily infested) and weeds within the house, and those outside the house, and all Horse Nettles near the house, were thoroughly cleaned up and burned. The soil in all the greenhouse beds was then thoroughly spaded and turned under several inches deep, and the house was heavily gassed with calcium cyanide. From that time until February the house remained open and unheated, although the outdoor temperatures were above normal during most of that period. In February, 1932, the house was warmed and planted with tomatoes. The writer made careful observations on the plants in this house during the spring and summer of 1932, and on the crop planted during the past fall, but no specimens of the injury nor of any stage of this pest have been seen during 1932, nor were any found by the owner and his workmen, who were especially instructed to look for them and to report them if found. Frequent careful examinations were also made of the Horse Nettles on this and adjacent farms during 1932, but no specimens of, nor injury by, this insect, were found in these weeds. From these observations it seems possible that the Tomato Pin Worm has been eradicated from this area. None have been found or reported elsewhere in southeastern Pennsylvania. This sudden disappearance of this pest may be attributed both to the thorough clean-up of this greenhouse and to destruction by cold due to freezing of the soil and the Horse Nettles during the late winter in March, 1932. It is probable that those found in these weeds during 1931 did not survive the

winter of 1930–1931 outdoors, but emerged from the infested greenhouse during the spring of 1931 and spread over the surrounding fields. Careful watch will be kept on this farm for any reappearance of this pest.

THE EGGPLANT LEAF MINER, *Gnorimoschema glochinella* Zeller. During the summer of 1932, while examining Horse Nettles on the above farm for evidence of the Tomato Pin Worm, the writer found the leaves of these weeds to be quite commonly infested with small larvae which resembled the larvae of *G. lycopersicella* Busck Many larvae were reared to maturity, and the resulting small moths were determined by Mr. Busck as *G. glochinella* Zeller. As there does not seem to be any published record of this insect having been taken in Pennsylvania, this note is published for its distributional interest. Jones (1923), who has given descriptions and illustrations of the stages of *G. glochinella*, lists the following distribution records of specimens in the U. S. National Museum collection: Kentucky; Wicomico Church and Norfolk, Virginia; Louisiana; Missouri; Colorado; Texas; California; Sinalao, Mexico. This insect is not mentioned by Leonard in the "List of the Insects of New York," nor by J. B. Smith in his 1909 New Jersey list Busck (1928) states that *glochinella* Zeller is confined to the eastern and southern parts of the United States, east of the Rocky Mountains. It is probable that the southwestern records noted above refer to *G. lycopersicella*.

G. glochinella is a pest, sometimes serious, of eggplants in the southeastern United States, as evidenced by records of their damage noted by Jones (1923) and by Walker and Gould (1931).

In southeastern Pennsylvania, the writer has found it fairly common locally in Chester County, in addition to the above farm near Coatesville where it was common this summer. Patches of Horse Nettle examined at a number of places in this county, however, failed to yield any specimens of this insect or its injury, indicating that it is not yet widespread in this part of Pennsylvania.

Jones (1923) lists the following parasites as having been reared from *G. glochinella* Zeller: *Chelonus phthorimaeae* Gahan; *Orgilus mellipes* Say; *Bassus gibbosus* Say; *Bassus sp.; Sympiesomorphellus bicoloriceps* Gir.; *Apanteles* sp.; and a solitary wasp, *Ancistrocerus fulvipes* Saussure.

From the *glochinella* larvae collected by the writer in 1932 were reared *Bassus gibbosus* (Say)—not common; *Microbracon gelechiae* (Ashm.), and *Microbracon melanaspis* (Ashm.), the last named being the most common. These were determined by C. F. W. Muesebeck of the National Museum.

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NAPHTHALENE FOR THE CONTROL OF THE ONION THRIPS

By FRANK B. MAUGHAN, *Ithaca, N Y.*

Excellent control of *Thrips tabaci* Lind. on onions was obtained by the use of crude naphthalene. Significant reductions in the infestation and increases in yield of the treated plats over the untreated plats were obtained. At each application the naphthalene was used at the rate of 200 pounds per acre. The most effective control was secured by applying the naphthalene directly on the row.

During the season of 1930 and 1931 a number of materials were tested to determine their effectiveness in controlling the onion thrips, *Thrips tabaci* Lind. Some materials were eliminated while others received further investigation according to the degree of control obtained. Crude naphthalene in preliminary tests showed evidence of being a very suitable insecticide for the control of onion thrips. During the past season more intensive tests with crude naphthalene were conducted near Goshen, in Orange County, N. Y., on the muck area, of approxi-

mately 3500 acres devoted mainly to onion culture. It is the purpose of this paper to present some of the results obtained.

GENERAL PLAN OF THE EXPERIMENT. Each experiment was divided into five plats consisting of 12 rows each and all plats were replicated five times to compensate for the variation in soils, degree of infestation and other ecological factors which might arise as the season progressed. Winds and floods are always a menace in this area. Each plat replicated five times represented two-fifths of an acre

METHOD OF TAKING DATA In taking the record of the effectiveness of each application count areas were established throughout the plats. These areas paralleled one another across all plats so that the data obtained might be statistically comparable. Population counts were made on the second day after each application of the crude naphthalene; the number of live thrips remaining on five plants in each of the count-areas being recorded.

The same procedure was employed in harvesting the yields An area twenty feet long from the middle four rows was harvested in each plat There were five such areas in each plat and these areas paralleled each other

All data obtained was treated statistically The method of Engledow and Yule in the Empire Cotton Growing Review, Volume 3; numbers 2 and 3, 1930 was followed The odds were calculated from an expansion table of T B. Wood, published in the Journal of the Board of Agriculture, supplement number 7, November 1911, London, England, prepared by Dr H H Love, professor of Plant Breeding, Cornell University

TREATMENT OF PLATS The crude naphthalene was screened through a common wire door screening to eliminate the lumps. The amounts for each plat was weighed separately. A saving of material and a more even distribution of the naphthalene over the plats was obtained by this procedure.

At each application the naphthalene was used at the rate of 300 pounds per acre. Each plat received three applications during the critical period of infestation. In this region this period comes from about July tenth to August fifth, varying slightly according to the season. The naphthalene was applied in the afternoon when the air currents were at a minimum and at a temperature ranging around 80 degrees F. Previous investigation showed that the naphthalene proved more effective on hot sultry afternoons than when the weather conditions are unsettled. The naphthalene was applied by hand, two procedures being employed. In plat number one (Table one and two) the

naphthalene was applied directly to the row so that some of the particles fell directly on practically every onion plant. In plats number two, three and four (Table one and two) the naphthalene was broadcast over six rows at a time. After each application the plants were examined in

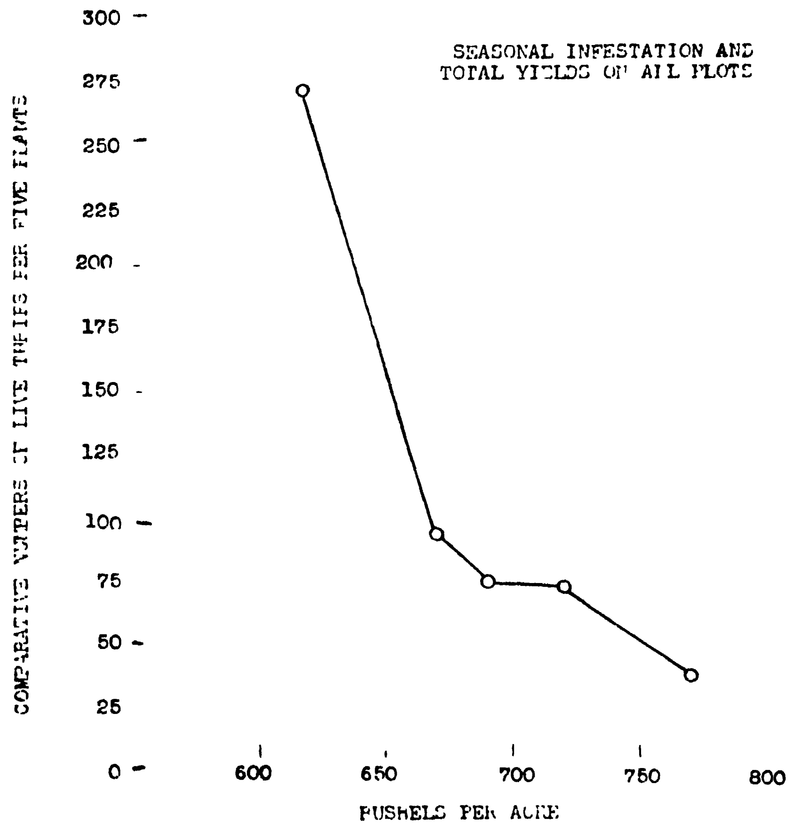


FIG 12. - Comparative nnmber of thrips and yields.

order to determine the distribution of the naphthalene. It was found that fifteen per cent more plants showed small particles of naphthalene deposited in the crevices of the younger leaves in plat one than those in the other plats. A study of the reduction of the infestation (Table one) and the increase in yield (Table two) between treatments emphasizes the importance of this method of application.

Observations made over a period of two years show that naphthalene is more toxic and repellent to the immature stages than to the adult thrips. The importance of depositing naphthalene on practically all onion plants is apparent because the earlier stages in the life history of

tabaci are passed in the crevices of the newly formed leaves. Controlling onion thrips depends upon depositing the insecticide where it will reach the immature forms.

DISCUSSION OF RESULTS. All the treated plats showed a significant reduction in infestation over the untreated (Table one). Inter-comparing treatments, plat number one was significant over plats two, three and four. None of the other treatments were significantly different.

The increases in yields roughly paralleled the reduction in infestation. All treated plats with the exception of number four, yielded significantly more bushels of onions per acre than the untreated plats. In comparing treatments, the application direct to the row was again significantly better than number two and four but not number three in point of yield. The differences between treatments two, three and four were again considerable but not significant.

The comparative number of thrips for the season and the total yields in bushels per acre on the untreated and treated plats are shown in Figure 12.

TABLE 1. REDUCTION IN AVERAGE NUMBER OF THRIPS PER FIVE PLANTS OF TREATMENT AT TOP OF TABLE, BELOW TREATMENTS AT SIDE OF TABLE, WITH THE ODDS THAT THESE DIFFERENCES ARE SIGNIFICANT

	On row No. 1	Broadcast No. 2	Broadcast No. 3	Broadcast No. 4
Check	226.5	198.	196.1	176.8
odds	9999:1	9999:1	9999:1	9999:1
Broadcast	49.7	21.2	15.3	
odds No. 4	1252:1	11:1		
Broadcast	30.4	1.9		
odds No. 3	66:1			
Broadcast	28.5			
odds No. 2	46:1			

TABLE 2. INCREASE IN YIELDS IN BUSHELS PER ACRE OF TREATMENTS AT TOP OF TABLE OVER TREATMENTS AT SIDE OF TABLE, WITH THE ODDS THAT THESE DIFFERENCES ARE SIGNIFICANT

	On row No. 1	Broadcast No. 3	Broadcast No. 2	Broadcast No. 4
Check	159.01	103.82	76.23	57.88
odds	9999:1	498:1	49:1	12:1
Broadcast	101.13	45.94	18.35	
odds No. 4	184:1	4:1		
Broadcast	82.78	27.59		
odds No. 2	40.1			
Broadcast	55.19			
odds No. 3	6:1			

It is apparent from the results obtained that naphthalene reduced the infestation of onion thrips, and the most effective control was secured by applying the material directly to the plants. While the increases in yield of the treated plats over the untreated plats are highly significant, the wide variation in the differences of the treated plats among themselves suggests that some other factor or factors unaccounted for enter into the problem. Further studies are needed to clarify these points.

MR. HEADLEE: I should like to inquire the number of treatments that were made, the time made, the degree of infestation and injury when the treatment started.

MR. MAUGHAN: We applied the materials in proportion to the damage caused by the onion thrips. There were three applications at approximately eight day intervals made to seed onions at the rate of 300 pounds per acre during the season. The period of infestation was about July 10th to August 5th. That period would vary slightly according to the season.

MR. HEADLEE: I should like to ask the speaker what, in his opinion, would happen if the treatments started after immense infestation had developed in adjacent fields and migration occurred from the adjacent fields into the field he was treating. Would he be able to hold them from coming in constantly?

MR. MAUGHAN: This field was surrounded on all sides by adjacent onion fields and we succeeded in holding the young thrips in check, and apparently they did not migrate into the field. The yield per acre in Orange County varies tremendously. In some experiments they ranged all the way from 400 bushels up to 900 bushels per acre. The time of harvest was three weeks after the last application. There was a faint odor of naphthalene still present, but apparently it did not have any detrimental effect.

FURTHER STUDIES OF TARNISHED PLANT BUG INJURY TO CELERY

By L. L. Hill, *Ithaca, N. Y*

ABSTRACT

Sulphur dust, 300 mesh or better when used alone as a dust or when combined with hydrated lime either as a dust or as a spray have been most effective in reducing tarnished plant bug (*Lygus pratensis*) injury in both early and late celery. An average of five applications was found necessary for control. The cost of material in every case is well within reason.

Further studies of control measures for the tarnished plant bug, *Lygus pratensis* L., were conducted in Wayne County, New York during 1932. These studies were primarily concerned with further testing those materials which gave the best control of the pest during the season of 1931. This paper presents a brief summary of two seasons work involving a total of eleven experiments.

Infestation. Large numbers of tarnished plant bugs emerged from hibernation in the spring of 1931. The spring brood was proportionately large, matured in June and flocked to celery fields where they oviposited in the celery. Injury caused by feeding punctures of both mature and immature stages appeared in all fields of untreated celery throughout the season. The spring infestation of 1932 was also very heavy and tarnished plant bug injury appeared in celery fields during July and the early part of August. Summer brood nymphs were very severely parasitised and late celery suffered lighter attacks because of this very decided decline in infestation. The infestation was so light during late summer and early fall that farmers were advised to discontinue applications of dusts and sprays. Celery harvested during the latter part of September 1932 showed very little tarnished plant bug injury, although it had not been protected for four or five weeks prior to harvesting. The third or fall brood was not so heavily parasitised and injury was severe in a number of fields harvested during the latter part of October.

Plan of Experiments. Five of the nine experiments, summarized in Table 1, were on a commercial scale with the plats varying in size from one to one-fourth acre, depending upon the experimental field. Plats in all of these experiments were in parallel strips across the fields and the treatments were replicated. Materials were applied by means of power sprayers and dusters. The remaining four experiments were laid out in Latin squares with each treatment replicated three times. The plats were two square rods each in size and the materials were applied by means of a hand duster and a hand sprayer. The size, ar-

rangement of plats and methods of applying materials for the two experiments summarized in Table 2 were the same as that just given.

RECORDS. In recording the number of injured leaves, counts were made from the middles of all plats in established count areas. These count areas were arranged in three parallel strips across all treatments. A total of three hundred plants were examined from each plat. The injured leaves were classified as follows; all leaves showing only a few punctures, practically no darkening of the leaf-stalks and the quality of the celery unaffected were called "slight;" leaves showing enough punctures to cause conspicuously darkened stems were classified as "moderate;" leaves in which the blackening, as a result of continued feeding, had covered most of the leaf-stalk so that injury was sufficiently severe to render the celery unfit for use were called "severe." Only those leaves showing no signs of feeding punctures were called uninjured.

RESULTS. Sulphur dust (300 mesh or better) when used alone as a dust or when combined with hydrated lime either as a dust or as a spray was most effective in reducing injury (Table 1). If slight injury, which does not materially affect the quality of the celery, be disregarded the amount of injury to plants treated with sulphur dust or combinations of sulphur and lime is commercially negligible. Sulphur when used alone as a spray has not given a very high percentage of control in any experiment. Lime as a dust and as a spray has not given satisfactory protection. Sulphur dust, sulphur and lime dust 50–50, and sulphur and lime spray 50 50 have in no experiment given less than 90 per cent control even in experiments where the percentage of injured leaves on the untreated plats ran as high as 70 per cent. The error given in Table 1 is the average standard error for the nine experiments. The amounts of materials per acre per application and the approximate cost of the materials for a total of five applications are given in the table. These amounts and costs per acre are figured for wide culture celery (36 inch rows).

Table 2 is a summary of two experiments to reduce tarnished plant bug injury to early celery during 1931. The injury here was not classified and all leaves showing feeding punctures regardless of whether they were slight or severe were called injured. It will be seen from the table that sulphur dust alone gave a very high percentage of uninjured leaves. Sulphur and lime spray 12–12–50 gave an average of 81.59 per cent of the leaves uninjured. It should be pointed out that the majority of the injury on celery treated with sulphur and lime spray was slight and since slight injury can be disregarded the percentage of control for this material is commercially satisfactory. Lime dust, sulphur spray and lime

spray did not result in sufficient reduction of the injury. The amounts of materials used per acre per application and the cost of such materials for a total of five applications are given in the table The error which appears at the end of the table is the average standard error for the two experiments

SUMMARY Large numbers of tarnished plant bugs were present throughout the season of 1931 and caused severe damage to both early and late celery The infestation was equally heavy for the first half of the season of 1932 but much lighter during late summer and early fall due to the fact that the second brood of tarnished plant bugs was heavily parasitised Sulphur dust, 300 mesh or better, when used as a dust and when combined with hydrated lime as a dust or spray gave excellent control of tarnished plant bug injury in both early and late celery. All dusts were applied at the rate of 75–100 pounds per acre and sprays at the rate of 100 gallons of solution per acre An average number of five applications was found necessary for control. The cost of materials varies with the combinations used, but in every case is well within reason

TABLE 1 SUMMARY OF 9 EXPERIMENTS TO REDUCE TARNISHED PLANT BUG INJURY TO CELERY DURING 1931 AND 1932

Material	Degree of injury to leaves: Slightly %	Moderately %	Severely %	Leaves clean %	Amount of material per acre	Cost of material per acre*
Sulphur and lime dust	3 80	1.49	13	94 58†	75 lbs	$ 9 00
Sulphur dust	4 60	2.56	.17	92 67	75 lbs	15 00
Sulphur and lime spray (50–50–100)	5.11	2 83	.39	91 67	100 gal	12 00
Sulphur and lime dust (25–75)	7 39	4 75	1 36	86.50	75 lbs.	6.00
Sulphur spray (1 pound per gallon)	10.94	10 69	1 36	77.01	100 gal.	20.00
Hydrated lime dust	15.05	12 34	2 79	69 82	75 lbs.	3.00
Hydrated lime spray	16.29	15.03	3 81	64.87	100 gal.	4.00
Untreated	19 65	27.79	9 81	42.75		

*Average number of applications 5. †Average standard error ±.71.

TABLE 2. SUMMARY OF TWO EXPERIMENTS TO REDUCE TARNISHED PLANT BUG INJURY TO EARLY CELERY DURING 1931

Materials	Leaves injured %	Leaves uninjured %	Amount of materials per acre	Cost of materials per acre*
Sulphur dust .	4.63	95.37†	100 lbs.	$20.00
Sulphur and lime spray (12-12-50)	18 41	81.59	100 gal.	5.76
Hydrated lime dust	23.74	76.26	100 lbs.	4.00
Sulphur spray (12 pounds in 50 gal.)	37.88	62.12	100 gal.	4.80
Lime spray (12 pounds in 50 gallons)	30.63	69.37	100 gal.	.96
Untreated	53.50	46.50		

*Average number of applications 5. †Average standard error ±.41.

OBSERVATIONS ON THE BIOLOGY AND CONTROL OF *METRIONA BIVITTATA* SAY

By L. A. STEARNS, *University of Delaware, Newark, Delaware*

ABSTRACT

A localized but destructive outbreak of The Two-Striped Sweet Potato Beetle, *Metriona bivittata* Say, near Laurel, Delaware, in 1932, is recorded as a further demonstration of the ability of this species to effect extensive damage. At the height of the infestation, during the first week in July, a Tachinid, *Anetia dimmocki* Aldrich was responsible for a 12 per cent larval parasitism. The results of a single application on July 6, to severely affected areas, of Lead and Calcium Arsenates, in dust form undiluted, indicate that both materials were practically 100 per cent effective for control of this insect and caused but slight injury to the plants. The acreage so treated on that date showed subsequently an almost complete recovery and produced a satisfactory crop.

The sweet potato crop in Delaware exceeds that of all other vegetables in value. It ranked fifth, in 1924, among all crops in the State and was one of the six crops (corn, wheat, hay, strawberry, sweet potato and apple) with a total of over a million dollars in value. Delaware has become the leading State in the yield of sweet potatoes per acre. Laurel, in Sussex County, is now the second largest, sweet potato shipping center in the United States. These statements by Gabriel—1929 (20),[1] in a report relating to the marketing of Delaware sweet potatoes and emphasizing the local importance of this industry, have a special entomological significance. The sweet potato crop in Delaware is the one large crop, which, year in and year out, has been practically exempt from insect attack. Growers in general, therefore, have not provided themselves with the necessary spraying equipment to prevent or to reduce losses of such a character.

On July 5, 1932, a complaint of excessively severe insect damage was received from one of the larger sweet potato producers in the Laurel district. Immediate investigation revealed that the infestation was decidedly localized and largely confined to a single field of approximately 48 acres and that the degree of injury was definitely associated with the proximity of affected areas to adjoining wooded and wasteland (Plate 4, A and B). The planting in question was of "Up River," the most popular strain of the Yellow Jersey variety in this locality. The field had been set about May 15 and growth to date averaged from 2 to 3 feet.

Although the insect population encountered included a number of the

[1]Numbers in parenthesis refer to Literature Cited included in Bibliography at the end of this paper.

"tortoise-beetles," (*Cassida*) *Metriona bivittata* Say, The Two-Striped Sweet Potato Beetle, was the predominating species, outnumbering all others approximately 10 to 1. All stages of the insect were present on this date. The capability of this pest to effect extensive damage was demonstrated by the fact that the plant centers had, in many cases, been almost wholly demolished, with leaves showing varying degrees of injury from partly eaten to completely skeletonized. In certain areas, no vestige of the plants remained (Plate 4, A and B).

Infrequent and fragmentary references in literature to the more or less sporadic activities of *Metriona bivittata* date back to about the year 1860. This species apparently occurs mainly upon the morning glory, bindweed and other members of the Convolvulus family and occasionally injures severely the foliage of related cultivated plants Complete records[2] (Plate 5, C) indicate that this insect is well distributed over the Mississippi Valley region as far north as southern Iowa and central Illinois and Ohio. It has also been recorded from the entire Atlantic seaboard from Florida to Massachusetts. In addition to eastern United States, it has been reported from southeastern Arizona. In the Middle Atlantic States, it has proved to be of but little importance as a sweet potato pest and usually is less numerous than the other species of the genus. During 1932, there appears to have occurred only the single, localized but destructive outbreak recorded herein for Laurel, Delaware.

The abnormal climatic conditions experienced in 1930 and 1931 may account for the unusual prevalence of this pest in sweet potato plantings during the summer of 1932. However, aside from increased population, there was no significant departure in the seasonal occurrence of the insect as previously recorded. The usual single generation developed in 1932. This species is known to hibernate as an adult in sheltered situations. The wooded and wastelands of the sweet potato area in southern Delaware afford conditions favoring successful hibernation (Plate 4, A). Overwintered adults were observed in abundance during late May and early June, in 1932. From the end of the second week in June until the close of the corresponding week in July, all stages of the insect were present—the egg, which is deposited singly on the leaf stems or on the under sides of the leaves along the larger veins and covered with a small, protective mass of black excrement; the larva or "peddler," with characteristic lateral spines or processes and its conspicuous anal fork, with excrement and cast skins adhering thereto, held over the back at an

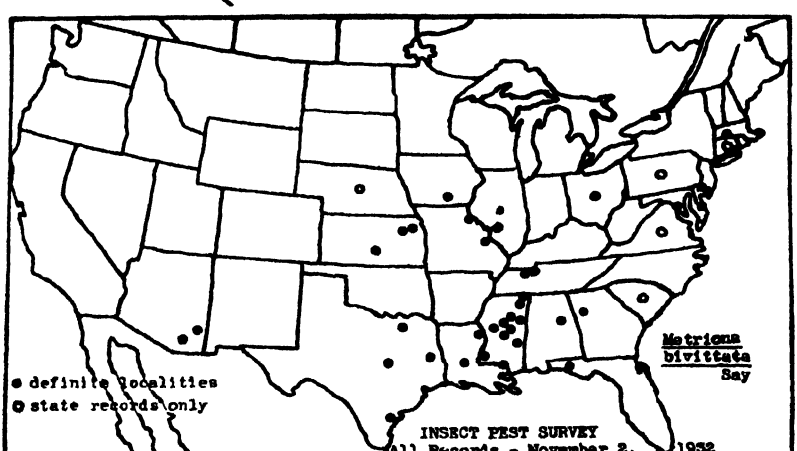
[2]Records of distribution included thru the courtesy of the U. S. Bureau of Entomology, Insect Pest Survey (J. A. Hyslop), complete to November 2, 1932 (Plate 2, C).

A.—Typical woodland closely adjoining sweet potato planting near Laurel, Delaware. Photographed July 6, 1932.

B.—Severely affected area in sweet potato planting near Laurel, Delaware, due to infestation by *Metriona bivittata* Say. Photographed July 6, 1932.

A


B


C


A—Sweet potato plant seriously injured by adults and larvae of *Metriona bivittata* Say. Photographed July 6, 1932. B—Sweet potato leaves partly eaten to completely skeletonized by adults and larvae of *Metriona bivittata* Say. C—Records of the distribution of *Metriona bivittata* Say complete to November 2, 1932; presented thru the courtesy of the U. S. Bureau of Entomology, Insect Pest Survey (J. A. Hyslop).

angle of about 45 degrees; the pupa with the larval skin attached posteriorly; and the adult, readily distinguished from others of this genus by the two black stripes on the dull yellow background of each wing cover. On July 15, approximately 90 per cent of the larvae had pupated and a few recently emerged adults were in evidence. Subsequent observations, on July 19 and 28, revealed few larvae, pupae in considerable numbers and a preponderance of wintering adults. By August 15, practically all of these adults had left the field and, on September 12, none could be located by careful search in the adjoining woods. A few specimens of the other, closely allied species were, however, collected feeding upon wild grape, wild cherry and sassafras. The sudden appearance of *Metriona bivittata* in early spring and its equally abrupt departure in late summer occasioned comment in the earliest accounts of the seasonal activity of this species.

At the height of the infestation, during the first week in July, a Tachinid, recently described by Aldrich (21) and determined by him as *Anetia dimmocki*, was responsible for a 12 per cent larval parasitism. This parasite had been reared previously only from species of related genera of the Cassidinae (Coleoptera; Chrysomelidae). Its occurrence, as recorded in the original description (New Hampshire, Massachusetts, Maryland, Virginia, North Carolina, Florida, Louisiana, Texas, Mississippi, Kansas, Ohio, Indiana and North Carolina), indicates a wide distribution thruout the area in which *Metriona bivittata* is known to be present.

Immediate dusting of severely affected areas was recommended on July 6. Six experimental plots, each 8 rows wide and extending the length of the field, were included to test the comparative efficiency of Lead Arsenate, White, Red and Green and Calcium Arsenate, White, Red and Green. These several materials were applied, on the date mentioned, undiluted, two puffs from a hand duster to each plant. Both the uncolored and colored Lead and Calcium Arsenates were apparently equally and approximately 100 per cent effective. No appreciable injury to the plants occurred. Subsequent observations, on July 15, 19 28 and on August 15 and September 12, indicated that the acreage treated, as described, made an almost complete recovery and produced a satisfactory crop. It would seem, from the results obtained, that a thorough dusting of sweet potato plantings during early June or before the larvae of *Metriona bivittata* have become sufficiently numerous to occasion severe injury would prevent a destructive outbreak such as that reported herein.

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Section of Apiculture

THE NEW BEEKEEPING

By E. F. PHILLIPS, *New York State College of Agriculture, Cornell University, Ithaca, N. Y.*

ABSTRACT

A discussion of developments in practical beekeeping methods based on investigations and experience regarding the need of colonies of bees in winter and spring, special attention being given to the size and arrangement of the hive. The two-story Langstroth hive is advised for winter, the upper story being filled with honey. A hive capacity smaller than this has been found not to yield the strongest colonies.

Having recently had opportunity to see various systems of beekeeping in other lands, I have been impressed with the importance of certain decisions which beekeepers have made, and have found cause for some congratulation that these decisions as made by American beekeepers have so often tended in the right direction. While we have much to learn from beekeepers and investigators of other countries, American beekeepers usually have stronger colonies of bees at the beginning of the major honey-flows than do most beekeepers of other countries, and it is recognized that strength of colony is the chief necessity in profitable beekeeping. Since most members of this Section are engaged in assisting beekeepers in improving their methods, a brief analysis of the methods and equipment which give best results seems in order, so that our ideas may be clarified and so that we may escape the pitfalls of bad advice.

The title used for this discussion has been used to designate those beekeeping practices which serve to stabilize honey production by providing for those factors of the honey crop which can be controlled by the beekeeper, and which give maximum financial returns for minimum labor. Some features of these methods are as old as beekeeping itself, but the combination is new. To discuss the details of and reasons for the components is entirely unnecessary before members of this Section, and all that will be attempted is a brief summary of the essential features with a few comments to explain the emphasis here placed on equipment.

Factors influencing colony development which are most vital to success in beekeeping are:

(1) Efficient wintering, including suitable fall management, (2) Development of colonies to the greatest possible strength prior to the honey-flow, (3) The prevention of increase in colonies for a period of about six weeks prior to and during a major honey-flow, usually by

means of swarm control, (4) Such renewal of queens as will insure uninterrupted heavy brood-rearing prior to the honey-flow, (5) Such arrangement of hive equipment as will induce maximum storage of honey, (6) Management of the colony at all times so as not to interfere with the best work of the bees, the suitability of their labor being judged from the standpoint of human economy.

Those features of apiary equipment which enable the beekeeper most easily to practice economically sound methods, which are most important in labor saving and which give maximum returns are:

(1) Good worker comb in brood frames to insure unrestricted brood-rearing, (2) Hives capable of contraction and especially of unlimited expansion as the needs of the colonies may dictate, (3) Complete uniformity of equipment, including frames of such size as to be suitable for use in all parts of the hive, (4) A hive suitable for both comb-honey and extracted honey production (not always important), (5) Simplicity and cheapness of equipment, (6) Labor saving machinery in the honey house

The use of the best beekeeping methods rests on the selection of the proper hive to a degree not usually appreciated. In the days when most beekeepers made their own hives and when there was a great diversity of hives in use in the United States, the hive problem was much debated, but of recent years little is said or written about it. In much of Europe it is still a burning question. Fortunately the decision made by the majority of American beekeepers is fundamentally sound, and the next step is to assist them in using the selected equipment fully and properly. The majority of American beekeepers use too small a hive and most of them never provide conditions so that a single colony reaches full strength at the beginning of or even during the honey-flow, and it is the privilege of those whose work it is to create a better beekeeping to help beekeepers correct their mistakes. The use of small hives results either in weak colonies or in unnecessary and totally unprofitable labor to the beekeeper.

In the United States it need not be argued that a hive opening at the top most easily permits unlimited expansion. Simplification of the hive by the elimination of every useless and ornamental feature seems to have been carried to the limit of possibilities, this having been done for purposes of economy of time and money, and the resulting hive when properly used is a suitable home for the bees and an efficient tool for the beekeeper. No hive which can be handled economically in summer is suitable for wintering bees efficiently in the North, so that winter insulation should be added. Double-walled hives are not much used and

their use is unsatisfactory except in the southern states where they are rarely encountered.

Increasing skill in beekeeping and the realization that bees require large amounts of honey and pollen for full development of colony strength before the honey-flow have led to the conclusion that a small hive cannot give satisfactory results. In the days of hives still smaller than any now used, many beekeepers regularly tried to make up for deficiencies of stores by frequent feeding in spring, a practice now considered unsatisfactory, useless, and even dangerous. Wherever small hives are used, beekeeping is an unimportant industry, and in all parts of the world where good honey crops are produced, larger hives are used. Mere size of hives is important, even though it be admitted that a skilled beekeeper can get good results with almost any hive if he works hard enough. The importance of the hive question depends chiefly on the suitability of the hive to beekeepers of average or less than average skill, but since such beekeepers everywhere constitute by far the majority, this makes the size of the hive in general use an important consideration.

A recent compilation of data on bee hives by Excellency Field Marshall Lieutenant von Mátyás of Hungary gives information on hives used in all parts of the world. He gives dimensions of frames and area of combs, as well as cubic content of the hive bodies containing ten frames. The comb surface on one side of a comb varies from the minute German "Normalmass" of 365 sq. cm to the Belgian standard frame of 1764 sq. cm. The capacity of the hive depends of course on the number of combs used for the various purposes. The Langstroth frame has a comb area of 913 sq. cm. and the Jumbo or Modified Dadant frame, 1147 sq. cm., both considerably smaller than the Belgian standard frame. When in Czechoslovakia recently I saw frames 60 x 60 cm. with a comb area of 3600 sq. cm., about four times that of the Langstroth frame, but this frame is not in general use, being merely an experiment.

It should first be emphasized that for winter there must be empty combs for the winter cluster and also for the storage of honey, enough to insure full development of the colony before the honey-flow. While in every locality there are years when nature supplies large amounts of nectar in spring, making large stores of honey in the hive unnecessary, it frequently happens everywhere that nature provides conditions when incoming nectar in spring is scant. This means that for safety the beekeeper must leave a large supply of honey, enough for the most adverse spring, and it is safe to say that few beekeepers have ever left enough.

The common practice of American beekeepers is to leave a little more than half the amount which will give maximum insurance of strong colonies, and as a result many beekeepers never see their colonies as strong as they should and could be. In teaching the New Beekeeping, one is always confronted by the dilemma of desiring to advise an amount of honey which will be safe and of having to exercise expediency in recommending an amount which the beekeeper will consent to leave, and a compromise is always required. It is increasingly evident that any amount less than fifty, preferably sixty, pounds is frequently inadequate, and such an amount necessitates a hive of large proportions.

Swarm control has been studied in the United States more than in any other country. This is largely due to the fact that in the period when comb-honey was generally produced, swarming was a more serious problem than at present, and the problem attracted the attention of our great bee masters Without exception, the best swarm control measures and most of the preventive measures are based on the transfer of combs from one hive body to another, necessitating either a divided brood chamber or the use of two separate hives, each of one hive body No single story deep frame hive is suited to these manipulations

Renewal of queens is growing in importance, because with the better colonies which result from good winter care and from proper stores for spring, the ability of queens to lay enough eggs is rapidly depleted. There is reason to believe that American-bred queens surpass in egg-laying ability most queens found in their native habitats, yet in spite of whatever improvement has been made in this regard, queens are often not good for two seasons. There is an increasing number of beekeepers who either desire or practice annual requeening. With the largest possible hive arrangement and with abundant stores, annual supersedure at the close of the honey-flow, when it does least damage to colony strength, is the rule rather than the exception, so that the chief task of the beekeeper in this respect is to see that the stock in the apiary is good. While supersedure in spring is a calamity, natural and timely supersedure eliminates much labor of a difficult nature.

Good worker comb is obviously desirable in the brood nest. With greatly improved methods of wax clarification and with the various methods of strengthening comb-foundation, the sagging of combs is becoming a less serious problem, and American beekeepers are fortunate in having available to them the best comb-foundations made anywhere, far superior to those usually encountered abroad. With modern comb-foundation, the last objection to the divisible brood chamber disappears. Sagging of combs is controlled with greater difficulty in deeper frames

than in the shallower ones, because of the greater weight of the combs and contents.

Adaptability of the hive to labor saving need not be discussed at length, except to repeat that the use of swarm control measures necessitates the use of a double brood chamber, and the result is that no brood chamber except one consisting of two hive bodies is open to the beekeeper for whom swarming is a problem. Since in all the better beekeeping regions of the North, swarming is too serious a problem to be neglected, there are few beekeepers who can afford to use a single hive of any depth for the brood chamber.

The question of unlimited expansion depends chiefly on the use of a hive opening at the top, so for American beekeepers this need not be considered at length. The limitation of frames suitable for extracting is one depending on the type of extracting equipment in use. Frames deeper than the Langstroth are not suited for our modern extractors, and when deeper frames are used for brood, this necessitates the use of shallow frames for surplus honey. The use of frames of two sizes is a nuisance and is not to be recommended unless it reduces labor or unless full strength of colonies cannot otherwise be obtained. Since the use of the Langstroth frame is satisfactory for both brood and supers, there is no excuse for the use of two sizes of frames Complete uniformity of equipment is a self-evident advantage, but it should if possible be carried to the point of having every frame in the apiary suited to every hive body.

Of all the things which a beekeeper does for his bees, none surpasses in importance the providing of abundant winter insulation and the supplying of more stores of honey than the bees will use in the most adverse spring. There have recently been abortive and sometimes laughable attempts to discredit the advantages of heavy winter insulation, but there is no scientific evidence that scant insulation is as good as heavy, and certainly none that insulation is unnecessary in cold climates. It is quite true that with the enormous colonies of bees which one can obtain by the use of a two-story hive and by supplying abundant stores, the bees can withstand much cold without showing heavy winter loss, but this is scarcely a valid argument for reducing or for abandoning heavy insulation.

The giving of enough honey for safety in adverse springs requires a large hive for both winter and spring, and it is coming to be recognized that even a hive as large as the Jumbo or even the slightly larger (11 frame) Modified Dadant is entirely too small to insure the best results. The fact that many good beekeepers often have fine colonies in the deep

hives merely means that in many seasons all the stores which for maximum safety should be left with the bees are not used because of the prodigality of nature with nectar in spring. In those years when spring nectar is scant, the users of the larger single story hives fail to get maximum returns, unless they go to the intolerable bother of spring feeding. Beekeepers who use the single story deep frame hives labor under the misinformation or the erroneous belief that there must surely be room enough for all colony requirements, whereas in at least a third of the spring seasons in northern states such hives are too small, because they cannot possibly hold both enough honey for safety and enough brood. While the deep hives are far superior to a single story Langstroth hive, it is undesirable to use them when there is a better hive at hand. The demands of the bees in adverse seasons and the enormous brood rearing ability of a first-class colony of bees leave no option for the beekeeper who wishes to use standard equipment except to use the two story Langstroth hive, the largest hive in common use anywhere

Stimulative feeding to make up for scant stores is still widely practiced, although it is a matter of congratulation that the practice has almost disappeared in America In those parts of middle Europe where hives of the Berlepsch type are still used, the practice is common and almost necessary. In the Soviet Union, where the Dadant-Blatt hive is standard, stimulative feeding is almost universal, but this is due to the fact that the beekeepers there do not leave honey enough to fill the space which this hive provides. In Great Britain, where a standard hive was adopted which is too small for full colony development when a single story is used, such feeding is still advocated These instances are mentioned to show that the fight for the New Beekeeping is not everywhere won.

The use of bees for pollination is increasing, this increase at present being best noted in the deciduous fruit regions. There is reason to believe that later this use must be extended to other agricultural crops. The pollination of deciduous fruits demands a service so early in the year that it is difficult to have strong colonies and it is usually impossible to have the colonies up to full strength. For this early pollination service, bees in single story hives of any dimension are rarely satisfactory, because in such hives it is impossible to get the colonies up to that strength which is entirely practical for this time of the year. Whereever the use of bees for pollination plays an important part in the selection of beekeeping methods, too great emphasis cannot be placed on the leaving of abundant stores for spring development and the providing of heavy winter insulation. The deciduous fruit areas of greatest

importance, and those in which the use of additional pollination agents is most felt, are all in regions where winters are rather severe. Those who fail to advocate and to use methods of beekeeping which yield enormous colonies at the time of fruit bloom are not serving the fruit growers effectually. It has been found practicable to have colonies containing over eight pounds of bees by the time of the opening of the apple blossoms, and such a colony provides a force of pollinating bees over four times as great as does a three-pound package of bees shipped from some southern location just in time for pollination use. Even though one cannot have all his colonies of this size at this season, especially if fruit blossoms open a little early, it has been found true everywhere that overwintered colonies which have had proper winter care and good stores in spring regularly furnish far more flying bees than will a package of bees of any size While it may be possible at rare intervals to get the greatest possible development of colonies in time for fruit blossoming in a story and a half Langstroth hive or in a single story Jumbo hive, in the majority of cases full strength at this time will not be attained in any hive smaller than the two-story Langstroth. In some cases it is even necessary to add a third Langstroth hive body before fruit blossoms open in order to give the colonies full opportunity to develop and to prevent swarming at this important time. To move such large hives to the orchards is extremely difficult, but small colonies are so nearly worthless for the pollination of fruit blossoms in most seasons that only the best colonies should be used.

Within the past few years there has been a great increase in the proportion of beekeepers who add a second hive body for spring stores, the second story being usually known as a "food chamber." Some beekeepers add a shallow super of combs, about half the capacity of the Langstroth hive while others add a full depth Langstroth hive body. The use of a shallow food chamber has been made to appear desirable in an effort to induce the beekeeper who formerly used one hive body in winter to take an advance step, but it has unfortunately had the effect in many cases of causing such a beekeeper to believe that he was doing all that can profitably be done. The shallow food chamber is a compromise and is not a suitable substitute for two full stories for winter and spring, the upper full of good honey.

The development of the New Beekeeping depends on investigations and experiences which have shown the superiority of the included methods over any other system of beekeeping so far found. Its adoption depends on the ability of its advocates to overcome the inertia of beekeepers who have practiced less acceptable methods. The human

element is more difficult to control than are the bees. Every advance in beekeeping has been ardently combated by good men, sometimes misguided but earnest and sincere. At times advances have been combated by publicity seekers who believe that by advocating the commoner methods of beekeepers they will increase their personal popularity. The inherent honesty of American beekeepers is the most hopeful feature in the development of better and better methods, and indicates merely what many of us have long known, that beekeepers are a fine group of people as a whole, among which there are only a few less honest and less dependable publicity seekers. But in all advances, the human element is harder to handle than the bees. Our problem in promoting beekeeping is one of applied psychology as much as it is bee behavior.

In selecting this subject in practical beekeeping for discussion at this time and in placing such strong emphasis on apparatus rather than some phase of the biology of bees, some slight apology may seem in order. Since the arrangement of the hive is based on our knowledge of the behavior and nutrition of bees, this is only the practical application of well established scientific facts. For a discussion which is commonly assumed to be general rather than specifically detailed in nature, no apology is required if through it there may come about a clearer appreciation of the privileges with which members of this Section are confronted. If we think these problems through to a proper conclusion, American beekeeping will profit thereby.

PRELIMINARY OBSERVATIONS ON "PARALYSIS" OF HONEYBEES

By C. E. Burnside, *Assistant Apiculturist, Bureau of Entomology, U. S. Department of Agriculture*

Abstract

Various divergent theories have previously been advanced regarding the cause of the disorder of adult honeybees commonly known as "paralysis." None of these theories have been supported by controlled experiments and practically nothing has been determined concerning the cause or even the nature of this disturbance of adult bees. Many beekeepers practice requeening affected colonies. This treatment is based on the belief that "paralysis" is a hereditary weakness for which the queen is responsible.

This paper reports experiments in which "paralysis" appeared to be successfully transmitted among bees in cages and among bees in colonies. Brood from affected colonies when placed in healthy colonies produced bees which remained healthy. Conversely, brood from healthy colonies when placed in affected colonies produced

bees many of which were later affected by "paralysis." The results obtained seem to indicate that "paralysis" of adult honeybees is a slightly infectious disease that is transmitted directly from sick or dead bees to healthy ones.

The disorder of adult honeybees commonly known as "paralysis" has been referred to in beekeeping literature for many years. Neither the cause nor a satisfactory method of treatment of the disorder is known although it is a very destructive disturbance of adult bees. Various theories regarding the cause have been advanced but none of these have been proved correct. Success has also been claimed for several methods of treatment but it is doubtful if any of these are of value. One method of treatment, namely, requeening, based on the belief that "paralysis" is a sort of hereditary disturbance resulting from failing or weakness of the queen, is practiced by some beekeepers.

During 1930, 1931, and 1932 the writer was able to make certain observations and experiments on this condition, the pertinent results of which are described below.

SYMPTOMS. The affected bees become "stupid," weak, and eventually flightless. Before reaching this stage, even in mild form, they can be recognized because of other bees which tug and pull at them excitedly. The sick bees make no defense but sometimes offer food or attempt to crawl away from their tormentors. Eventually they are driven out or else crawl onto the top bars or into a semi-quiet corner of the hive. Sick bees may either retain their hair or become partially or nearly hairless before death occurs; they may thus vary in appearance from normal, young-looking bees to old, hairless ones with shining, swollen, greasy, or translucent abdomens. *The most characteristic symptoms are decided trembling of the body and wings, particularly when accompanied by weakness, sprawled legs and wings, hairlessness, and dark, greasy-looking abdomens.* These symptoms are not present in all the sick bees but such bees can usually be found in badly affected colonies. The microorganisms known to cause diseases of adult bees were absent.

EXPERIMENTS WITH COLONIES. During 1930 and 1931 experiments were conducted to determine (1) if "paralysis" is caused by poisonous or poor-quality stores; (2) if the condition is infectious and, if so, what is the cause and how it is transmitted; (3) if the queen is in any way responsible for "paralysis."

Early in September, 1930, a colony of Italian bees in the experimental apiary of the Bee Culture Laboratory, Somerset, Md., became badly affected by "paralysis." Other colonies in the apiary were slightly affected. Two combs nearly filled with honey and pollen were taken from the sick colony and given to a small colony which had previously

been placed on two sheets of foundation. At the same time practically all the honey in the sick colony was removed and replaced with stores from a healthy colony.

The colony confined to stores taken from the sick colony failed to develop symptoms of "paralysis" at the end of 10 weeks. On the other hand, the death rate among bees in the sick colony was not reduced after two weeks.

To determine whether the condition is infectious or is one for which the queen is responsible, three combs of brood from the sick Italian colony were exchanged with 3 combs of brood from a healthy Caucasian colony on September 26. Symptoms did not develop in the Caucasian colony among either of the two races of bees during the remainder of the active season. On the other hand, the death rate from "paralysis" in the Italian colony continued at about the same rate throughout the season. Sick Caucasian bees were observed in this colony within a week after emergence and after about two weeks symptoms of "paralysis" among these bees were unmistakable. The death rate among the Caucasian bees increased gradually until it appeared to be about equal to the death rate among the Italians. By October 15th, 50 to 100 sick bees showing characteristic symptoms of "paralysis" were seen daily in or near the entrance to the hive. During November the death rate decreased and the colony was united for winter.

In June, 1931, two nuclei of hybrid bees, one of which was very weak on arrival, were received at the Bee Culture Laboratory from Nevada. Sick bees showing symptoms thought to be typical of "paralysis" were present in both nuclei and experiments, devised to determine if the condition was infectious, were begun immediately. The bees in each of the nuclei were placed on combs of sealed brood taken from healthy Italian colonies. Two small colonies of healthy Italian bees and queens were placed on the combs which came with the Nevada bees. These two colonies increased in strength and symptoms of "paralysis" were not observed among either the hybrid or Italian bees during the remainder of the active season. The weakest of the two colonies prepared with hybrid bees from Nevada died before the first Italian bees emerged. The death rate decreased among the hybrid bees of the other stronger colony. After 8 days a few sick Italian bees were found near the entrance. On the 12th, 13th, and 14th days after this colony was prepared, 8 or 10 sick Italian bees showing trembling and other symptoms resembling symptoms of "paralysis" were observed in and about the hive. Within three weeks, however, this colony recovered completely.

In July, 1932, a colony of Italian bees in the Government experimental apiary at Somerset, Md., was affected by "paralysis." The death rate was high for about three weeks, after which the disorder continued in a milder form. On September 6th this colony was requeened with a Caucasian queen and on October 13th and 14th a few young Caucasian bees were observed weak and dying near the entrance. Observations were discontinued until October 31, when the characteristic symptoms of paralysis were observed among the Caucasian bees in this colony. The disturbance continued affecting both Italian and Caucasian bees until about November 15th.

SICK BEES MAY RECOVER. That occasional bees appeared to recover after showing marked weakness and trembling was observed in the course of the experiment A similar observation was made in southern Georgia in 1932 by R E. Foster (state apiary inspector of Florida) and the writer. Several colonies which were seriously affected by "paralysis" in March and April showed considerable improvement or recovery in May. One colony when inspected during the last week of April showed all the worker bees weak and trembling and apparently none of them were gathering nectar or pollen. The queen appeared normal and was laying well. Plenty of stores were in the combs but none of the cells was supplied with brood food and no brood was being reared. A week later the bees in this colony appeared much improved, although no brood was being reared at this time. The colony was being robbed and to avoid further robbing it was moved to a new location and supplied with a small amount of sugar syrup. Three days later the bees appeared entirely normal and brood food and hatching larvae were present. The development of this colony for three weeks thereafter appeared normal. The same adult bees which in April showed marked symptoms of "paralysis" and made no attempt to attend to the duties of either field or hive bees recovered completely by May and resumed the duties of both nurse and field bees.

EXPERIMENTS WITH BEES IN CAGES During 1930 and 1931 bees in cages were used in the following experiments·

In October, 1930, about 250 bees (shaken from the combs and of various ages) were placed in each of 9 wooden cages covered with screen at the top and bottom. Bees in 2 of these cages were kept as checks while the bees in 7 cages were inoculated, using an extract prepared by macerating bees sick and recently dead of "paralysis" in a small quantity of water, and straining through cloth. In the case of bees in 3 cages the extract was also passed through a porcelain filter. This extract was either fed to the bees in sugar syrup or sprayed onto them.

The cages were kept at room temperature, about 22°C. (71.6° F.), until all were dead. The difference in death rate between the inoculated bees and those in the check cages was insignificant and symptoms of "paralysis" were not produced.

In each of three other cages prepared by covering a petri dish with a wire screen, 5 or 6 bees sick of "paralysis" were confined with about 50 healthy ones and the cages kept at room temperature. Symptoms of paralysis were not produced among the healthy bees and the death rate was normal for bees in cages.

In other experiments in 1930 about 20 1-day-old bees were placed in each of 5 cages prepared by covering a petri dish with screen and heavy paper. The bees in 4 cages were inoculated by puncturing the thoracic wall with a sterile needle and transferring to the wound on the needle a small drop of blood from the thorax of a bee sick or recently dead of "paralysis." The bees in a check cage were punctured in the same manner but a small drop of sterile water was placed in the wound. Fifty per cent sugar syrup was used for food. The cages were kept at room temperature for 11 days and then placed in an incubator at 35°C. The average length of life among the inoculated bees in different cages (after eliminating those that died of septicemia) was 6.9, 8.3, 9.0, and 9.9 days. The average length of life for the check bees was 11.3 days. The higher temperature appeared to increase the death rate among inoculated bees, whereas the checks were unaffected. In addition to the higher death rate among the inoculated bees, symptoms of "paralysis" (trembling and sprawled legs and wings) was observed in about 20 per cent of the bees before death occurred. These symptoms were not discernible in the checks.

In colonies affected by "paralysis" worker bees are frequently observed tugging and pulling excitedly at other workers, some of which appear normal while others show characteristic symptoms. In one cage were placed 20 apparently normal bees which were being tugged at and in another cage 20 bees which were doing the tugging. In the former case, after the bees were placed in the cage, they were observed to be decidedly more sluggish than in the latter case and the death rate was nearly twice as high at 35°C. (95°F.) as among the other bees which appeared normal and died at a normal rate for bees in cages.

The following experiments with bees in cages were conducted in 1931. The cages were prepared with the idea of reducing excess ventilation by covering a petri dish with screen over which was placed a circular piece of cardboard of the same diameter as the dish. Food was supplied from a vial through a small hole in the cardboard.

About 30 1-day-old bees, Italians or Caucasians, were placed in each of 6 cages. Fifteen sick hybrid bees showing typical symptoms of "paralysis" from nuclei received from Nevada were added to each of four cages (3 cages of Caucasians and 1 of Italians). For four days the cages were kept at room temperature after which they were kept in an incubator at 35°C. (95°F.). Within 8 days after this experiment was begun definite symptoms of "paralysis" developed among 100 per cent of the Italian bees and among approximately 50 per cent, 25 per cent, and 25 per cent, respectively, of the three cages of Caucasians. The death rate was approximately twice as high as among two cages of Italian bees kept as checks under similar conditions. Symptoms of "paralysis" did not develop among the check bees.

In each of 8 other cages 50 1-day-old Italian or Caucasian bees were confined with 10 sick bees in which "paralysis" was artificially produced in the experiments described above. The sick bees were either marked or were of a different race than the healthy ones. Two cages were kept at room temperature for 3 days and at 35°C. (95°F.) thereafter while four other cages were kept continuously at room temperature. After 7 days fully 20 per cent of the bees in the cages kept at 35°C. (95°F.) showed typical symptoms of "paralysis." About 10 per cent of the bees in two cages kept at room temperature showed symptoms of "paralysis" after 9 days, while no such symptoms were observed in two other experimental cages kept at room temperature. The death rate among the bees in these six experimental cages was also somewhat higher than among check bees in two cages kept continuously at room temperature.

In another experiment 50 1-day-old Italian bees were placed in each of 8 cages. These bees were sprayed until wet with an extract prepared by macerating in a small quantity of water and straining sick and dead bees showing typical symptoms of "paralysis" produced artificially in the experiments described above. Two of these cages of bees were kept at room temperature and 3 cages at 35°C. (95°F.). Within a week definite symptoms of "paralysis" developed among 100 per cent of the bees in one cage kept at 35°C. (95°F.) and among approximately 90 per cent and 50 per cent of the bees in two other cages kept at room temperature. About 20 per cent of the bees in two cages kept at room temperature showed symptoms of "paralysis" before death. Three cages of bees were kept as checks at 35°C. (95°F.) and the bees in two of these cages were sprayed with sterile water. The death rate among the check bees was considerably lower than among the inoculated bees and symptoms of "paralysis" did not develop among any of them.

About 50 1-day-old Italian bees in each of seven other cages were in-

oculated with a sterile extract prepared as described above and in addition filtered through a porcelain filter. The bees in three cages were inoculated both by spraying with the extract until wet and by mixing the extract with their food which consisted of dilute sugar syrup. These three cages were kept at 35°C. (95°F.). The bees in two cages became smeared with syrup that leaked from the feeders, and this tended to complicate results. In all three cages, however, the death rate was higher than among check bees in two cages kept at room temperature, and after about one week from 10 per cent to 20 per cent of the bees showed symptoms thought to resemble symptoms of "paralysis."

The bees in four cages were inoculated by spraying with the filtrate Three of these cages were kept at 35°C. (95°F.) and one at room temperature. Definite symptoms of "paralysis" were not produced among any of these bees and the death rate was about the same as among the checks.

DISCUSSION. Since these experiments are preliminary and the results obtained were not always constant, it is with hesitancy that the writer attempts to interpret them. The following statements regarding the significance of these results are therefore tentative and not intended as a final conclusion.

"Paralysis" of adult honeybees appears to be a slightly infectious disease transmitted directly from sick or dead bees to healthy ones

Brood appears not to be affected and the disorder is not readily transmitted to healthy colonies by changing combs of brood or stores

Affected bees may either die quickly or linger in a weak condition for several days before death, or they may recover.

A PLANT POISONOUS TO ADULT BEES

By G. H. VANSELL, *Associate Apiculturist*, and W. G. WATKINS, *Field Assistant, Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

Bees moved into the Sierra mountains of California in 1932 suffered an abnormal death rate while visiting the blossoms of western false hellebore (*Veratrum californicum.*).

Numerous instances of an abnormally high death rate of adult bees have occurred over the entire country. In many cases the trouble has been traced to arsenical materials, but often no cause for it has been

[1]A severe dearth of nectar occurred there in 1932, whereas an excellent crop of honey had been stored from western hyssop (*Agastache urticifolia*) in the identical locations the previous year.

indicated by either microscopical or chemical analyses. One case of high mortality which came under observation during the summer of 1932 yields evidence against a plant as the causative agent.

Some apiaries moved up into the high Sierra Nevada Mountains of Eldorado County[1] from valley and foothill locations suddenly showed a serious loss of adults. A death rate of 51 returning field bees per minute was sustained at one hive during a short period on the morning of August 2. The bees died soon after dropping and were found in a curled position similar to that assumed by a bee which has been stung by another. Some were unable to get into the hive after reaching it; others entered and climbed upon the combs but dropped off within a few seconds. Down between the combs, bees could be seen clinging feebly by the forelegs; a slight jar caused them to fall upon the hive bottom. Those colonies which remained in the original locations were normal throughout, and affected colonies became normal when moved down from the mountains

A high death rate was maintained for three days, after which there was a gradual decrease An occasional colony continued to lose adults for three, four, or five weeks Some of the colonies apparently lost most of their field force during the first three days of the attack (August 2, 3, and 4), the source of the trouble being thereafter practically cut off as far as these units were concerned. The brood suffered no apparent ill effects. By far the greatest number of deaths must have occurred before the bees were able to reach the hives.

The duration of the outbreak may have been further limited by a natural circumstance. A buckwheat brush, *Eriogonum umbellatum*, growing on sunny exposures close to the bee yards burst into blossom on August 5. This plant yielded a moderate supply of nectar, which the bees eagerly sought.

Field search revealed bees, both black and yellow, upon and below the blossoms of *Veratrum californicum* (western false-hellebore, often known locally as corn lily). Some were dead; some, dying, were hanging helplessly by their front legs. This plant grew in large patches on the wet lands immediately surrounding small lakes as well as along the streams above and below them. The flats containing these lakes were at the top of precipitous slopes 1,000 feet above the apiaries. During the outbreak the flight of the bees was upward and directly toward this higher country; and, since the Italian bees taken to the mountains were easily distinguishable from the black bees already present, the evidence is positive that the yellow bees on the plants came from the Italian colonies.

Each leaf of *Veratrum californicum* forms a sheathlike cup about the

stalk below the terminal panicle of blossoms. The uppermost of these receptacles was found to contain the bodies of numerous dead insects other than honeybees, including ants, beetles, and flies. The field evidence that some substance highly toxic to insect life is associated with the blossoms of this plant appears conclusive. Investigation of this substance from the standpoint of its toxicity to insect life is suggested. The plant is often reported as poisonous to stock, but is ordinarily considered unattractive to bees. It is recorded in high mountain meadows from northern Washington east to Colorado and south to Mexico.

Evidence that a number of plants are, at times, responsible for trouble in the apiaries is in process of accumulation. Some of them—for example, California buckeye—chiefly affect the brood, while others result, either directly or indirectly, in the death of both adults and brood. The instance recorded here shows that sometimes the adult field population alone may be concerned.

NECTAR SECRETION OF THE TULIPTREE OR YELLOW POPLAR

By G E. Marvin, *Assistant Apiculturist*[1] *Bureau of Entomology, United States Department of Agriculture*

Abstract

Because of the large amount of nectar flow observed from the tuliptree (*Liriodendron tulipifera*), an experiment was undertaken to determine the quantity of nectar secreted per blossom and the sugar content of this nectar. The average weight of nectar secreted by one flower was 1.6417 grams The average sugar content of nectar from freshly opened blossoms was 16.7 per cent. After the flower was open the concentration of the nectar increased until on the second day it reached 35.9 per cent. The tree under observation was calculated to yield sufficient nectar to produce 2.16 pounds of honey.

To one standing near a tuliptree at the height of the blooming period when a gentle breeze is stirring the branches, the falling of drops of nectar gives the impression of a light rain. During favorable seasons nectar is present in the tuliptree blossoms in such quantities that wild insects and honeybees cannot carry it away as fast as it is secreted; consequently much nectar is lost.

In the vicinity of Washington, D. C., the tuliptree or yellow poplar (*Liriodendron tulipifera*) blooms the latter part of May, and black locust

[1]Credit should be given to Jas. I. Hambleton, Senior Apiculturist, in charge of the Division of Bee Culture, Bureau of Entomology, U. S. Department of Agriculture, for suggestions and help given during the course of the experiment.

comes on at approximately the same time. For the last two seasons it has been observed that, when the bees started gathering nectar from the locust, they continued working on it in spite of the preponderance of nectar available from the tuliptree They therefore did not gather a full crop of honey from this tree

FIG. 13 A close-up of the tuliplike blossom of the tuliptree, showing a portion of the conelike pistil and the numerous stamens.

Because of the copious nectar flow from the tuliptree making it an important honey source, and because of its prevalence in the neighborhood of the Bee Culture Laboratory, an experiment was conducted there to find out the quantity of nectar secreted per blossom and the sugar content of this nectar.

DESCRIPTION OF FLOWER. The numerous flowers of the tuliptree, opening in May, resemble tulips having six greenish-yellow petals (Fig. 13) arranged in two whorls to make a bell-shaped corolla.

Approximately 15 mm from the base of the petals there is an orange-colored strip 4 to 5 mm. wide, forming a band around the cup. In

freshly opened flowers many small droplets of nectar appear on the inner orange-colored surface, indicating that the nectaries are located there. As these droplets become larger, adhesion not being strong enough to hold them to the petal, they run down and collect in the corolla of the flower.

QUALITY OF HONEY PRODUCED. The honey produced from the nectar of the tuliptree is of a reddish-amber color, is of full but good flavor, and is mostly marketed locally. During the last two seasons it was observed that soon after the trees were through blooming the leaves were attacked by an aphid, *Illinoia liriodendri* (Mon.)[2], which secreted large quantities of honeydew. The aphids appear on the young growing tips and, on account of the conical shape of the tree, much of the honeydew is caught on the lower leaves. Numerous blackened, yeastlike forms[3] producing mycelium grow on these leaves, causing them to become discolored and to fall prematurely. If the beekeeper does not remove the surplus honey from the tuliptree soon enough, its quality may be injured by the honeydew.

METHOD OF EXPERIMENTATION. Each evening the large buds which appeared ready to open the following morning were covered with cellophane to exclude bees or other insects and rain. The flowers were tagged as they opened; so their ages were known at all times. After each collection of nectar the cellophane was replaced.

The weight of the nectar in the flowers was obtained by absorbing it in small wads of absorbent cotton. Several hundred wads ½ inch wide, 4 inches long, and 3/8 inch thick were prepared, wrapped in lots of five, and placed in the oven to dry. Each lot was designated by a letter and each wad in a lot was numbered. When the wads were thoroughly dry, they were weighed and then placed in a desiccator until they were used, in order to prevent absorption of moisture from the atmosphere. A wad of cotton was withdrawn from its package with a forceps and packed into the corolla of the flower. With a little practice this could be done without injuring the petals, pistil, or anthers. The weight of the nectar was obtained by weighing the wads of cotton with the nectar and subtracting the weight of the cotton.

The nectar for the sugar determinations was gathered from the flowers by means of small glass pipettes. The sugar content was determined by the use of the Abbé refractometer. The refractometer

[2]Identified by P. W. Mason, Bureau of Entomology, U. S. Department of Agriculture.

[3]A pure culture of this organism is in the stock collection of E. B. Fred, University of Wisconsin.

measures the refractive index, and by means of Schönrock's table[4] for determining water in sugar solutions, the water content of the nectar was obtained. By subtracting these readings from 100 per cent the sugar content was obtained.

WEIGHT OF NECTAR. For the 32 blossoms under observation the total weight of nectar secreted per blossom ranged from 0.4748 to 3.1626

TABLE 1. WEIGHT OF NECTAR SECRETED BY TULIPTREE BLOSSOMS OPENING ON VARIOUS DAYS

Flower No.	Date of opening	Weight of nectar, in grams — First day A.M.[1]	First day P.M.	Second day A.M.	Second day P.M.	Total
1	May 18	0.9012	0.9272	0.1636	0.0910	2.0830
2	20	1.7215	.3352	.2259	———	2.2826
3	20	.8674	——[2]	1.2570	.1636	2.2880
4	20		.4438	1.2458	———	1.6896
5	21	1.5915	——	.4762	———	2.0677
6	23	2.1228	.4363	.1708	———	2.7299
7	23	.5882	.0236	———	———	.6118
8	23	1.6754	——	.6037	———	2.2791
9	23	.6976	——	.0327	———	.7303
10	23		1.0716	.3271	.1871	1.5858
11	23		1.2895	.8637	———	2.1532
12	23	.2211	.4690	.5365	———	1.2266
13	24	1.5799	——	.2319	———	1.8118
14	24	1.7478	——	.4192	———	2.1670
15	24		.3512	1.3007	———	1.6519
16	24		.6293	2.5333	———	3.1626
17	24		.4506	.9532	.1087	1.5125
18	25	.6045	——	.7860	———	1.3905
19	25	.4913	.3950	.2317	———	1.1180
20	25	1.5216	——	.1562	———	1.6778
21	25	.9302	——	.4907	———	1.4209
22	25	.7123	——	.6752	———	1.3875
23	25	1.5543	1.2485	.3373	———	3.1401
24	26	1.7548	——	.7839	———	2.5387
25	26	1.1949	——	.6372	———	1.8321
26	26	.5005	——	.7672	———	1.2677
27	26	.4409	——	.1433	———	.5842
28	26	.3242	——	.1506	———	.4748
29	26		.4529	.5042	———	.9571
30	26		.6359	.3777	———	1.0136
31	26		.5908	.2688	———	.8596
32	26		.3611	.4674	———	.8285
			Average for flowers opening in a.m.			1.6872
			Average for flowers opening in p.m.			1.5414
			Average for all flowers			1.6417

[1]Blank spaces indicate that the flower did not open on the morning of the first day.
[2]Dashes indicate that the flower was dry when examined.

grams, the average being 1.6417 grams. (Table 1.) Twenty-two of the blossoms opened in the early morning and yielded nectar having an average weight of 1.687 grams, whereas 1.5414 grams was the average total yield for the 10 opening in the afternoon.

[4]Association of Official Agricultural Chemists, Methods. Ed. 3, Reference Table 6, p. XLII. 1930.

Nectar was found in the flower during the first day it was open and the following morning. If this nectar was removed, the blossom remained practically dry from that time on.

TABLE 2. WEIGHT OF NECTAR IN TULIPTREE BUDS, TOGETHER WITH WEATHER CONDITIONS, AS THE BUDS WERE UNFOLDING

Flower No.	Temperature °F.	Humidity Per cent	Weight of nectar Grams
Buds opening on morning of May 27			
36	82	60	1.0179
37	83	57	.7429
38	83	57	.7040
39	84	55	.3466
40	85	54	.9266
41	85	54	1.1820
42	86	53	.8038
43	87	52	.4611
44	88	47	.7417
45	88	47	.6928
Average			.7619
Buds opening on morning of May 28			
47	74	50	1.5329
48	74	50	.4880
49	75	49	1.2110
50	76	48	.9415
51	77	47	1.2049
52	77	46	.9596
Average			1.0563
General average			.8723

Inasmuch as nectar was present in freshly opened blossoms, 16 large buds that were just unfolding were examined. Quantities of nectar ranging from 0.3466 to 1.5329 grams were already present, the average weight for the 16 buds being 0.8723 gram. (Table 2.) Ten of the buds were opening when the temperature ranged from 82° to 88°F. and the humidity ranged from 60 to 47 per cent. The average weight of nectar secreted by these 10 buds was 0.7619 gram. The other six unfolded while the temperature ranged from 74° to 77°F. and the humidity from 50 to 46 per cent. The average weight of nectar secreted for this group was 1.0563 grams. All these flowers opened in the early morning, but one morning was much warmer than the other. Buds which were large but in which the sepals had not yet begun to loosen were found to be dry of nectar.

SUGAR CONTENT OF THE NECTAR. The sugar and water contents of the nectar are found in Table 3. The nectar gathered from freshly opened flowers contained from 15.2 to 19.5 per cent sugar. The uncollected nectar became more concentrated the longer it remained

in the open flower and by the second day the nectar had a sugar concentration of 35 to 36 per cent. In a blossom apparently neglected by the bees nectar was found which had a sugar concentration of 63.9 per cent.

Nectar in freshly opened blossoms is colorless, as the white cotton wads were not discolored. After the nectar had remained for four hours or more in the opened flower, it became light yellow.

CALCULATION OF HONEY OBTAINABLE FROM TREE UNDER OBSERVATION. The tuliptree under observation was 15½ inches in diameter 5 feet above the ground. During the blooming season, from May 16 to June 6, 1932, the limb on which this work was conducted had a total of 108 blossoms and, as there were 23 limbs of approximately the same size,

TABLE 3. SUGAR CONTENT OF NECTAR IN TULIPTREE BLOSSOMS, TOGETHER WITH WEATHER CONDITIONS, DETERMINED AT VARIOUS TIMES

Flower No.	Date	Time of taking nectar	Temperature °F.	Humidity Per cent	Refractive index of nectar	Composition of nectar: Water Per cent	Composition of nectar: Sugar Per cent
			Flowers freshly opened				
1	May 18	3:30 P.M.	68	32	1.3588	83.2	16.8
2	19	8:30 A.M.	58	58	1.3598	82.5	17.5
3	20	11:00 A.M.	68	45	1.3580	83.6	16.4
5	23	2:30 P.M.	74	32	1.3580	83.6	16.4
6	24	9:00 A.M.	72	55	1.3588	83.2	16.8
8	24	2:00 P.M.	82	43	1.3594	82.8	17.2
13	27	8:30 A.M.	77	66	1.3560	84.8	15.2
15	28	9:00 A.M.	72	56	1.3548	85.6	14.4
16	28	9:30 A.M.	74	56	1.3630	80.5	19.5
Average						83.3	16.7
			Flowers opened two hours				
11	May 25	11:00 A.M.	85	52	1.3668	78.2	21.8
14	27	10:30 A.M.	88	50	1.3642	79.8	20.2
17	28	11:00 A.M.	75	48	1.3662	78.6	21.4
Average						78.9	21.1
			Flowers opened four hours				
4	May 20	3:00 P.M.	76	36	1.3770	72.3	27.7
7	24	1:00 P.M.	80	45	1.3712	75.6	24.4
9	24	2:30 P.M.	83	43	1.3750	73.4	26.6
10	24	4:30 P.M.	80	44	1.3790	71.2	28.8
12	26	1:00 P.M.	89	48	1.3719	75.2	24.8
Average						73.5	26.5
			Flowers opened the previous day				
	May 25	—	—	—	1.3910	64.6	35.4
	31	—	—	—	1.3927	63.6	36.4
Average						64.1	35.9
			Flower apparently neglected by the bees				
	May 23				1.4507	36.1	63.9

the tree was calculated to contain a total of 2,484 blossoms. As the average weight of nectar secreted per blossom was 1.6417 grams, it was calculated that 4.1 kg., or 9.02 pounds, of nectar was secreted by this tree. Since the average water content of nectar from freshly opened flowers was found to be 83.3 per cent, and honey is considered to have an average moisture content of 20 per cent, it was calculated that the nectar secreted from this tree would make 2.16 pounds of honey.

Summary of Results. The total weight of nectar secreted by tuliptree flowers ranged from 0.4748 to 3.1626 grams. The total yield of nectar from flowers opening in the cool of the morning was greater than from flowers opening in the heat of the day. Nectar was found in freshly opened flowers, the quantity present for 16 flowers ranging from 0.347 to 1.533 grams, the average being 1.056 grams. The 10 flowers opening at higher temperatures, 82–88°F., had an average yield of 0.762 gram, whereas the 6 opening at 74–77°F. had an average yield of 1.056 grams.

The sugar content of the nectar from nine freshly opened blossoms ranged from 14.4 to 19.5 per cent, the average being 16.7 per cent. The concentration of the nectar increased after the flowers opened, until on the second day the average concentration was 35.9 per cent.

It was calculated that the tuliptree under observation would yield sufficient nectar to produce 2.16 pounds of honey.

A Cage for Confining Weevils on the Fruit and Foliage of Trees. A simple cage that has proved satisfactory for caging adults of the pecan weevil on growing nuts and foliage for insecticide tests was made by cutting two openings in a paper bag and covering each with wire screen. The bag used was a grocery bag of Kraft paper, 25-pound size. At the lower end of each of the narrow sides was cut a rectangular hole 5½ inches long by 3½ inches wide, leaving a ¼ inch margin of paper on the two sides and bottom. A piece of black lacquered wire screen, with 12 meshes to the inch, cut the same width as the narrow side of the bag, was applied to the outside of the margins with shellac. A strip of paper sealing tape 1 inch wide was put over the four edges of the screen. It has been found that black screen renders objects within the cage more clearly visible to the observer than galvanized wire. In use, the cage with insects is placed over the end of a tree branch and tied with one string.

Nearly 100 cages were used during the past season for short periods. One series was used for 12 days, during the first 3 of which the cages were exposed to 0.96 inch of rain. No cage was harmed by dissolving the glue or tearing the paper. The cage allows ventilation and observation, and furnishes space for making notes on the outside of the bag, obviating the use of an identification tag. For storage the cage may be collapsed laterally, opposite to the original folding of the bag.

Theo. L. Bissell, *U. S. Bureau of Entomology, Experiment, Ga.*

FURTHER NOTES ON THE BEE MOTH

By F. B. PADDOCK, *Ames, Iowa*

ABSTRACT

Recent information obtained on distribution, life history, parasites and control methods of this pest (*Galleria mellonella* L.) are presented.

This pest of the apiary has wrought unusually severe damage during the past three years thruout its entire distribution. It is hard to determine just what are the factors which have permitted this insect to cause such abnormal destruction. A large number of insect pests have been unusually serious probably as a result of climatic conditions. It is assumed that the two mild winters have resulted in a reduced mortality and a resultant building up of population. This has been coupled with adverse crop conditions which caused insect damage to be more accumulative. It is highly probable that the mild winters have permitted a higher survival of the bee moth for it is known definitely that cold is fatal to moths and even the protected larvae and pupae. It is known that moths will emerge during warm spells in the early spring which shows that their development is responsive to temperature changes. It is further true that there have been three more or less unfavorable seasons for honey production. The direct result of this is that many extracting combs were not taken from storage and placed on the hives. It can be said that the general colony condition has been below average with an abnormally large percentage of weak colonies. Both of these factors are conducive to moth activities.

Two outstanding examples might be cited as typical of Iowa experiences. A large producer took off honey soon after the summer flow had stopped abruptly. Before extracting was started much damage was done by larvae, indicating that the infestation occurred in the apiary. The supers were returned to colonies for cleaning but the bees did not combat the worms so destruction of combs in 200 supers was complete. In the other instance there was no need for some 400 deep supers of combs which remained in the hot honey house. Before mid-summer, when examination was finally made, destruction of the combs was complete. Not only were the combs a total loss but the labor item for reconditioning this equipment was a large one. The consumption of comb by the larvae under such conditions is enormous.

DISTRIBUTION: Similar conditions must have prevailed throughout much of the United States from the indications of increased corre-

spondence and as more inquiries were received by the magazines for control methods of the moth. Some new observations have been made on the biology of this insect, especially in the western portions of the country. This corresponds with observations made in other countries that the pest is more severe in dry hot areas.

This insect must have been active in many countries judging by the references to it in literature. Recent studies have been made in Norway, Denmark, Germany, France, Italy and in four provinces of Russia on some phase of control. The pest seems to be more destructive in Egypt and Palestine, where a reorganized apiculture is meeting many old problems. Special attention has been accorded this insect in Brazil, Argentine and Paraguay on the South American Continent. Modern apiculture in Japan is facing the ravages of the bee moth. The pest is now recorded from Java. Records from additional provinces of India show a general distribution of the pest there where *Apis indica* is readily attacked.

PARASITES: Interesting developments have occurred in parasite relations of the bee moth. Studies made on the corn borer by Hase show that the chalcid egg parasite, *Trichogramma evanescens* Westw. can be bred throughout the year on *Galleria mellonella* L. The recorded hosts of this parasite number 65 species but to date field records indicate no effective reduction in the bee moth through the agency of this parasite Another chalcid parasite, *Pseudochalcis dirceunae* is recorded by Bertoni in Paraguay from the cocoons of *G. mellonella* It is said that this parasite has a wide distribution in South America. There is no indication of how general or effective this parasite is in the control of the bee moth. Observations made in France by Metalnikov indicate that certain micro organisms are transmited to *Galleria* larvae by the puncture of *Dibrachys boucheanus* Ratzb. Picard records in France the parasite *Apanteles hoplites* Ratzb. reared from bee moth larvae. He has also reared *A. lateralis* Hal. from the same host. These parasites do not appear to be operating sufficiently under field conditions to check the ravages of the bee moth.

Hase working further on corn borer parasites says that in ten experiments a high degree of parasitism was found on *G. mellonella* L. by *Microbracon libetor* Say. It seems that under field conditions this parasite confined its activities to the corn borer. This parasite has been taken from bee moth larvae at Davis, California by Vansell in 1926 and has been collected at Orange, California by Bishop. Further findings of this parasite have not been recorded in that state. Knowlton in Utah

in 1931 records laboratory observations of this parasite on the bee moth larvae. He observed as many as 16 parasites from one *Galleria* larva.

Further experiments conducted by Hase carried out over a period of three years demonstrated that *T. evanescens* Westw. can be bred entirely from eggs of *Galleria*. After this period the parasite was effective against the corn borer in the field. When offered eggs in the laboratory no preference was shown by the parasite which indicates that it could be effective in checking the bee moth but it has not developed under field conditions. Two and three parasites were observed within a single egg.

Behavsky in Germany records *Eupelmus cereanus* Rond, as a parasite of the bee moth. He says that since 23 to 25 days are necessary for the development of the parasite in the larvae, that it would be possible to send infected larvae to localities where the parasite is not known. Thus it would contribute to the control of the bee moth in such districts There is no indication that such measures were effective if they were attempted.

DISEASES: Several research workers in France have reported that the bee moth larvae died from an epidemic. This was first reported in 1911 by Metalnikov. He reported to have isolated two organisms which he designated as a rod and a coccus. In 1922 he conducted experiments to prove that reinoculation of his isolated organisms did produce the disease. He suggested then the possibility of using it for the control of the bee moth. A second epidemic of a disease occurred later among the larvae of the bee moth. Two organisms were isolated, one named *Bacterium galleriae* and the other left as a *Micrococcus*. In experiments each organism caused death of the larvae. These organisms were studied further by Chorine in 1926 when he identified *B. galleriae* and named *Streptococcus galleriae*. The next year he isolated another organism which he called *B. subtilis galleriae*. These three organisms were shown to be pathogenic to the larvae of *Galleria* under laboratory conditions.

Later in experiments with diseases of the corn borer, Chorine found two species, *B. canadensis* and *B. ontarioni* to be toxic to bee moth larvae when injected in a diluted bacterial emulsion. In general the larvae of the bee moth showed more resistance to the diseases than did the corn borer larvae. *Micrococcus curtissi* was not very effective against the bee moth larvae. It would seem that diseases in the control of the bee moth may be as elusive as they have proved to be in the

attempts to combat other insect pests. It is interesting that forms have been identified with the bee moth.

CONTROL: Fumigation seems to be the general method of attempting the control of the bee moth. The popular recommendation in Germany is for the use of hydrocyanic acid gas for the reason that it is effective against all stages of the insect. No particular concern is expressed regarding the dangers associated with the use of this material. The material recommended by the French is chloropicrin. This is placed on top of the infested material which is in a tight receptacle. The liquid is poured on blotting paper on a plate and the exposure is 24 hours. This material is considered more practical and certain than sulphur, "para" or tetrachloride. Chloropicrin is effective against all stages but eggs and tetrachloride must be added to kill them. A novel scheme is proposed for use in Italy. Dilute sulfuric acid, 2 parts and 1 part water. is placed in a glass receptacle. This is placed with the combs to be fumigated and sulfate of lime is added after which the container is sealed. Sulphrous acid is evolved as when flowers of sulphur are burned but there is no danger of fire.

Many materials have been recommended in the United States. Burning sulfur was used over a long period, but the danger of fire was too great. Carbon bisulfide was next used but it was even more of a hazard. The use of para became quite general but was rather ineffective. Next it was recommended to use a combination of ethyl acetate and carbon tetrachloride as there was no fire hazard and it was effective. This material was not generally available so did not grow in popularity. The use of calcium cyanide seems to be quite general now and it is effective. This material is cheap and generally available.

LIFE HISTORY: Some interesting observations have been made on the general life history of this pest in some of the foreign countries. In France it is said that moths are little known, and never injurious, in the high valleys, nor on the mountains. But they attack and destroy a vast number of hives in the plains where they are a great scourge. This conforms to the general principle proposed a few years ago that there seems to be a limiting factor to the distribution of this insect. This factor is correlated with higher altitudes. All records indicate a decided overlapping of broods. Moths of a second generation will emerge and oviposit while larvae of varying ages from the first generation are still in the combs. The moths are not conspicuous during the early part of the summer but do attract attention during late summer and autumn. The moth is reported in Germany to be active in the apiary from June

to September, but they are found in the honey house in combs in April. The worms are destructive in stored combs throughout October and all sizes of larvae are present. In Don Province of U. S. S. R., in the southern part with a latitude equal to Duluth, Minnesota, moths are seen in the apiary in May.

Damage by this pest in Argentine is much more severe in the hot, dry areas, one record is given where 80% of the hives were lost in one season. The first generation of moths in Japan appears in the spring and the second generation in summer and early autumn, indicating a long period for the second brood. It is reported that breeding is continuous throughout the year in the warmer parts of New Zealand.

The ravages of the bee moth are especially severe against *Apis indica* in China, Java and throughout India. It is said that this bee from its nature of operations, does not protect itself against the moth. They are more prone to swarming and so leave their open nests with few bees to continue the fight with the moth.

BUCKEYE POISONING OF THE HONEYBEE—A PROGRESS REPORT

By J. E. Ecker,[1] *Division of Entomology & Parasitology, University of California, Davis*

Abstract

The poisonous effect of the California buckeye on the honeybee was shown to have a cumulative effect on the queen to the extent of either preventing the egg from hatching or so weakening the larva that it died soon after hatching. All queens of the same race or of hybrid stock were not affected alike as some showed greater resistance than others. The sap of the buckeye was shown to be poisonous to bees but no bees were observed to gather it after it had oozed from punctures made in the stems by *Irbisia solani* Heid.

A study of the California buckeye, *Aesculus californica*, in relation to beekeeping was first undertaken by Vansell of the Division of Entomology and Parasitology of the University of California, in 1923, and reports of the findings were issued in 1925[2] and in 1926.[3] It was shown conclusively in these reports that wherever the buckeye is abundant it is

[1]The writer wishes to acknowledge the helpful assistance given by A. S. Harrison, C. F. Harbison, and W. C. Hale in recording a portion of these data.

[2]Vansell, G. H. Buckeye Poisoning of the Honeybee in California. American Bee Journal, 65: 575–578, 1925.

[3]————. Buckeye Poisoning of the Honeybee. Calif. Agri. Exp. Sta. Cir. 301, 1926.

seriously injurious to the queen, drones, workers, and brood of bees during seasons when other plants fail to produce enough nectar to be more attractive to the honeybee than this plant, the effects becoming increasingly severe with the greater amount and the concentration of the buckeye products brought in from the field. Different strains of Italian bees were used in these early experiments.

As reported by Vansell,[3] "The effects on bees of buckeye honey, pollen, nectar, and sap are sometimes severe. Not only the field bees, but the adult queen and drones are affected as well as the larvae and emerging young adults In severe cases the whole colony dies with the hive full of honey The majority of the larvae being fed are killed outright and are in the main devoured by the adults. These young which are not killed will pupate and emerge, if they are not so badly deformed that they are unable to do so Adults with but four normal legs are very common. The wings of practically all emerging young never expand. Many of the adult bees become weak and die in the hives They are carried out by the survivors and dumped in front of the entrance in a great pile. Many of the surviving bees are deformed and seem to lack normal instincts, for they crawl out of the hive and away from it, going toward the sun and to the tops of weeds and grass to remain until they die. The field bees seem at times to be affected the least, possibly because they are more resistant than the larvae However, nearly all of them later become unable to void fecal material and they assume the 'shaky' attitude of paralytic bees It is a common experience to find an abnormally large number of dead bees upon buckeye blossoms in the field, especially near the end of the honeyflow. The queen's egg laying power is cut down to almost nothing, a condition which leads to attempted supersedure The resulting young queen is often unable to fly or in case she is able to take the mating flight, she lays only a very small number of eggs. Drones that are able to fly are apparently weak in flying powers. They do not appear normal in any respect. In fact, with severe poisoning, the demoralization of all the individuals in the colony is often complete."

Subsequent experiments[4] by Todd and Vansell indicated that the adult worker bees were not seriously affected and[5] that Carniolan x Italian hybrids were more resistant than Caucasian x Italian hybrids.

[4]Todd, F. E., and Vansell, G. H. Data concerning one method of apiary management for use in the California buckeye area. Journ. Econ. Ent., Vol. 25, pp 500–502, 1932.

[5]Vansell, G. H., and Todd F. E. Resistance of Hybrid Honeybees to a Plant Poison in California Journ. Econ. Ent., Vol. 25, pp. 503–506 1932

It was also found by the same authors that many colonies recovered from the effects of buckeye poisoning when moved from buckeye territory if the buckeye stores were removed from their hives. A majority of the colonies that were not given a new set of combs dwindled to extinction.

The importance of the California buckeye as a honey plant and especially the value of other plants within the great area covered by the California buckeye, justifies continued observations regarding the effect of buckeye poisoning on bees The relative resistance of certain crosses and the possibility of perfecting a better method of management within this territory offers fertile fields for future experiments. The present experiments were made for the purpose of continuing work on the relative resistance of the Caucasian, Carniolan, and Italian races and their crosses to buckeye poisoning and to secure more specific information on the manner in which the malady affects a colony of bees.

METHODS. On May 10, five Carniolan x Italian and five Caucasian x Italian colonies containing an average of four frames with brood and 5 pounds of bees, together with three Italian, one Carniolan, and three Caucasian colonies, as checks, were moved into a buckeye location south of Vacaville, California. Frequent observations were made during the next three months as to the condition of the brood and bees and changes in hive weights. Observations were taken in the field and at the hive to determine the sources other than the buckeye from which bees could secure nectar and pollen, and on the behavior of the honeybee while visiting the buckeye. The effect of sap from the buckeye stems when fed to caged bees was also noted. When the colonies were moved from the buckeye location, their brood combs containing honey and pollen secured in the buckeye location were not changed, with but one exception, although the surplus honey was extracted.

RESULTS. Examination of pollen samples collected from bees during the first month in buckeye territory indicated that bees from all colonies made frequent visits to the wild radish, *Raphanus sativus;* mustard, *Brassica campestris;* milk thistle, *Silybum marianum;* California poppy, *Eschscholtzia californica;* Christmas berry, *Photinia arbutifolia*, and the buckeye, *Aesculus californica* and less frequent visits to five species of plants whose pollens we have not been able to identify. No samples of buckeye pollen were obtained from returning bees until six days after the colonies had been placed on location although the bees were observed gathering nectar from the buckeye during this period and may have gathered some of the pollen as well. More pollen samples were secured of the radish, mustard, milk thistle, and California poppy than for the buckeye.

These plants were in bloom during the first part of the experiment while the yellow star thistle, *Centaurea solstitialis*, was the dominant nectar and pollen plant during the last three weeks when the buckeye bloom was practically gone. The California buckeye was the principal honey plant until the yellow star thistle came into bloom although the bees secured some nectar from several of the other plants from which they secured pollen, and especially from the mustard. The prevalence of the other plants noted above was not sufficient to make them significant as major sources of nectar even though the bees did secure considerable pollen from them.

The first symptoms of buckeye poisoning were observed nine days after the bees were moved to the buckeye location when an increased amount of pollen was noted in the brood combs, accompanied by a slight reduction in the amount of unsealed brood. A week later many empty cells were found scattered among the brood, resembling the work of an old queen. After the third week, these conditions increased markedly and there was a striking scarcity of larvae between the 36-hour and 4-day old stages and malformed, "buckeyed," bees were in evidence in and in front of all colonies The buckeyed[6] bees were particularly abundant in the Italian colonies. In practically every case of malformation, the adherence of a portion of the last molted skin to the body of the bee was noted. Sometimes the entire abdomen was encased in this pupal skin and at other times a portion of the thorax as well as the abdomen was enclosed. Adult bees with "paralytic"[7] symptoms were numerous in front of the hive and especially in front of the Italian colonies, many of them having distended abdomens and some being practically devoid of hair. Buckeyed and paralytic bees were less numerous after the sixth week.

Three of the Caucasian x Italian queens were most seriously affected although one Caucasian queen, the daughter of an imported queen, was also very seriously affected. Three of the Caucasian x Italian colonies attempted to supersede, two were successful while the third became hopelessly queenless. One Caucasian x Italian colony, No 21, was less affected than the other three and was able to increase in numerical strength during the period.

[6]The term "buckeyed" is here used to mean the adult bees malformed because of the effects of buckeye poisoning.

[7]The term "paralytic" bees is here used to denote those bees affected in a manner similar to bees having the well-known, but little understood, malady called paralysis. The symptoms probably were not caused by the buckeye directly but rather to a preponderance of old bees induced by reduced brood rearing.

The Caucasian queen most seriously affected continued to lay at a reduced rate and deposited, at times, more than one egg in a cell. Many of the eggs did not hatch and the larvae from the few that did hatch soon died. This colony had become so weakened by the end of the fifth week that it was about to be overcome by yellow jackets. It was moved out of the buckeye territory on July 16 and given a new set of combs with two frames of emerging brood.

The other two Caucasian colonies, Nos. 32 and 33, Table 1, were less seriously affected than the Carniolan or Italian colonies or the crosses resulting from mating Caucasian and Carniolan queens with Italian drones. Colony No 32 increased in strength and maintained a good average production throughout, as is shown in the accompanying table.

The fact that the Carniolan colony was more seriously injured than the crosses between Carniolan and Italian colonies or the pure Italians, was interesting. It was stronger in numbers at the beginning than any of the Carniolan x Italian nuclei but stored less after the fourth week. (See Table 1.) Attempts were made at supersedure but the cells were destroyed in order to save the queen.

On three separate occasions, a section of comb, about 4 x 5 inches in size and containing eggs only, was taken from the Caucasian colony most seriously affected and introduced into a hopelessly queenless colony at University Farm, Davis, that had never been exposed to the effects of buckeye poisoning A few of the eggs hatched but the larvae died within a few hours after hatching.

On three occasions, frames containing eggs from other colonies in the buckeye location were placed in colonies at University Farm, Davis, and although a portion of the eggs either did not hatch or the larvae died soon after hatching, from 50 to 75 per cent of the eggs produced normal, mature bees. Ten normal queens were reared successfully at Davis from fifteen larvae grafted from a frame of eggs brought from the buckeye region.

The plant bug, *Irbisia solani* Heid., was abundant on the stems of the buckeye bloom but repeated observations failed to show that any of the bees collected the exudations of sap from the stems made by its punctures. Feeding trials in which caged bees were offered the juice of crushed stems of the buckeye, indicated a higher death rate when bees were exposed to either sap alone or to sap and sugar syrup than when bees were offered sugar syrup or just water. The straight sap seemed very "distasteful" to the caged bees as they would back away immediately after touching the liquid with their tongues and would stroke their

tongues with the forelegs. To the human taste, buckeye sap is extremely bitter.

RECOVERY OF QUEENS FROM THE EFFECTS OF BUCKEYE POISONING. The Caucasian queen in Colony No. 34 which was moved to Davis on July 16 and given a new set of combs with two frames of emerging brood, began to lay more normally within three days and by November 10 had built up a colony of average strength. The combs containing buckeye honey and pollen were given to an Italian colony that had not been exposed to buckeye poisoning. Although symptoms of buckeye poisoning developed, this colony has used up much of the pollen and buckeye honey and was of average strength by November 10.

During the last two weeks of the time the colonies were located in the buckeye region, the bees gathered considerable pollen and nectar from the yellow star thistle and only a very small amount of buckeye nectar and pollen. Egg laying increased and the percentage of larvae that reached maturity became more nearly normal. Buckeyed and paralytic bees became very scarce The honeyflow from yellow star thistle continued until the latter part of October at Davis and the colonies continued to store honey.

An examination of these colonies on November 10 showed that one Carniolan x Italian queen had been superseded but that the four remaining queens of this cross had normal colonies of average numerical strength. The Caucasian x Italian colonies were much weaker than the others, the Caucasian colonies were of average strength while the Carniolan colony was average but somewhat weaker numerically than the Caucasians or Carniolan x Italian colonies. The three Italian colonies were stronger and apparently had made a better recovery.

SUMMARY. During the season of 1932 colonies exposed to nectar and pollen from the California buckeye, had access to pollen and nectar from other flowers. This tended to reduce the severity of effects of the buckeye poisoning as described by an earlier writer.[2] The Carniolan x Italian cross proved more resistant than the Caucasian x Italian cross, with the exception of one Caucasian x Italian colony. One Carniolan and one Caucasian colony were more seriously affected than the Carniolan x Italian cross or the pure Italian colonies while two Caucasian colonies were less seriously affected than any of the others.

No bees were found to collect sap from the buckeye made by punctures of the plant bug, *Irbisia solani* Heid. Feeding experiments with caged bees indicated that juice from crushed stems of the buckeye was quite poisonous when taken by the bee and that the bees would not take it unless induced to do so by hunger.

It was demonstrated that in extreme cases the cumulative effects of buckeye poisoning on the queens might either prevent the eggs from hatching or so weaken the larva that it dies soon after hatching even though placed under favorable environmental conditions. The queen thus seriously affected was able to recover sufficiently to maintain a colony when moved from the buckeye region and given new combs, while the remaining queens recovered their normal functions, at least sufficiently to maintain colonies of average strength, when their colonies had access to other sources of nectar and pollen without the removal of the combs containing buckeye honey and pollen.

Net Change in Weight in Pounds of Colonies in a Buckeye Location Near Vacaville, California, Between May 13 and August 8, 1932

Colonies	Periods						
Caucasian* x Italian	5/13–28	5/28–6/11	6/11–25	6/25–7/9	7/9–23	7/23–8/5	Totals
21	16.25	10.50	13.75	12.00	14.00	22.25	88.75
22	8.00	3.25	3.50	1.50	(–).25	—	16.00
23	13.00	6.00	3.25	(–).50	(–).25	0	21.50
24	4.75	4.25	4.75	5.00	7.00	4.00	29.75
Totals							158.00
Average							39.50
Carniolan x Italian							
26	12.00	8.00	11.00	1.00	7.25	23.75	63.00
27	14.00	3.75	10.00	7.25	12.00	28.00	75.00
28	15.00	4.75	5.50	2.75	9.50	26.00	63.50
29	10.00	9.00	4.50	2.75	7.25	20.50	54.00
30	8.50	15.00	8.50	5.50	20.00	37.00	94.50
Totals							350.00
Average							70.00
Carniolan							
31	13.75	9.00	1.50	(–)4.50	(–)1.50	11.50	29.75
Caucasian							
32	25.00	27.25	23.25	14.25	29.75	57.00	176.50
33	8.00	34.00	19.50	15.50	0	25.00	102.00
34	11.75	21.00	5.00	13.25	—	—	51.00
Totals							329.50
Average							109.83
Italian							
35	16.50	15.00	7.75	5.75	(–)4.50	13.00	53.50
36	5.00	4.75	7.50	(–)3.25	24.00	37.50	75.50
37	24.00	8.00	(–)0.50	(–)3.50	(–)5.00	16.00	39.00
Totals							168.00
Average							56.00

*One Caucasian x Italian colony was found to have a crippled queen, and was omitted from this table.

STUDIES ON THE RATE AT WHICH HONEYBEES RIPEN HONEY[1]

By O. W. PARK, *Ames, Iowa*

ABSTRACT

Recent studies show that the peculiar activity of housebees in manipulating nectar with their mouthparts accounts for the fact that honey when first deposited in the comb is considerably more concentrated than was the nectar from which it came. Nectar containing 45 per cent sugar when brought into the hive was found to contain approximately 60 per cent sugar when first deposited in the comb. Other results show that combs of green honey left in the hive but screened from the bees, advanced in concentration from 65 per cent to 80 per cent, the concentration of ripe honey, within 3 days.

This is a progress report on the subject of honey-ripening as carried on by the honeybee, *Apis mellifera*. Many have assumed that a considerable part of the excess water of nectar is eliminated by some physiological process while in the honeysac of the field-bee, so that formerly it seemed necessary that a study of the water elimination process should begin with the field-bee. Recently, however, the writer[2] has shown that instead of becoming more concentrated, the nectar in the honeysac of the fielder actually becomes slightly more dilute. Consequently the problem of how bees remove water from nectar begins only after the nectar is delivered within the hive.

Previous reports by the writer have shown: (1) That manipulation of nectar by house-bees prior to its deposition in the comb is a factor in the water elimination process; and (2) that sugar solutions of various concentrations lose water at a rapid rate when put into normal honeycomb cells and placed within the hive but screened from the bees. But no concrete evaluation of the manipulation of nectar by house-bees has been given heretofore and data on the rate of evaporation of water from green honey newly deposited in the comb have been lacking. The purpose of the present paper is to report progress on the last two mentioned phases of the problem.

For the sake of clarity in the following discussion, it becomes necessary to define the terms *nectar* and *honey* as used herein. Since the change from nectar to honey takes place gradually over a period of many hours, the question arises as to just when nectar ceases to be nectar and becomes honey. Apparently the answer is that an intermediate stage exists which has no name. Some consideration was given

[1]Journal Paper No. B 92 of the Iowa Agricultural Experiment Station.

[2]Park, O. W. Studies on the Changes in Nectar Concentration Produced by the Honeybee, *Apis mellifera*. Part I. Res. Bul. 151, Iowa Agr. Exp. Sta., 1932.

to the invention of a new term which could be applied to the transition stage when the product is no longer nectar in its original state nor is it yet honey. While the use of such a term might have certain advantages, it was thought best to avoid this step for the present if other suitable terminology could be found. As defined by the United States pure food law, honey must not contain more than 25 per cent water, but the sugary solution placed in the comb by the honeybees is universally thought of as honey, almost regardless of water content. Beekeepers often use modifying terms such as new, unripe or green, to describe honey which is not ripe. In line with the above usage, it is suggested that the term nectar be used to apply to the sugary liquid gathered from flowers up to the time the product is deposited in the comb when it may be referred to as green honey or unripe honey until its concentration approximates that of ripe honey. The terms nectar and honey as used in this paper conform to the usage suggested above.

The general plan of this study was to determine the sugar concentration of the nectar when carried into the hive, the concentration of the green honey when first deposited in the comb and then at intervals until the concentration of ripe honey should be attained.

Sugar concentrations were determined by means of an Abbé refractometer. Determinations on incoming nectar were made as follows: Between 15 and 20 loaded bees were captured as they alighted at the hive entrance and killed in a cyanide bottle A sugar determination was then made upon the contents of each honeysac until the concentration of 10 loads of nectar had been found and recorded. The mean of these was taken as the concentration of the incoming nectar for that period. It was found necessary to determine each load individually in order to eliminate the loads of water which were being brought in by some of the bees. It was not unusual to find from one to five water-carriers in each lot of bees, hence the need of catching more bees than the number to be recorded.

The colony used in this work was prepared as follows: At 4 p. m. on July 18, a nucleus containing a laying queen and about a pint of bees, was installed in a 10-frame Langstroth hive on 2 frames almost completely filled with brood, 1 frame of unsealed honey and 7 frames of foundation. An abundance of young bees (house-bees) was added by shaking bees in front of the nucleus from about a dozen frames taken from a neighboring colony. Old bees flew home but the young ones joined the nucleus. At 8 o'clock the following morning, a strong colony was removed from its stand and this small colony put in place of it. Thus the field force was added automatically in such a way that no ripe

or partially ripe honey would be carried over into the experimental hive.

Smoke was not used either in connection with the preparation of the special colony or later when removing combs or returning them. This precaution was taken in order to avoid causing the bees to fill their honeysacs with honey already stored, because the admixture of such honey would reduce the accuracy of the results.

A number of combs of honey had been extracted and the empty combs thoroughly washed and dried several days in advance. Three of these were used in this experiment and were designated by the numbers 101, 102 and 103, respectively, in the order in which they were used. At 12 o'clock, noon, on July 19, the one comb of unsealed honey (which had served to catch whatever nectar the bees were ready to deposit) was removed from the experimental colony and was replaced by Comb 101. The colony then occupied a hive devoid of all honey except a few cells in the corners of the two frames of brood.

Comb 101 was removed from the hive at 1, 2, 3 and 4 o'clock to determine the concentration of the green honey which had been deposited during a known time interval. On each of these occasions, except the last, the comb was completely emptied by means of a fine pipette, and after thoroughly mixing all the honey obtained, the sugar determination was made from this composite sample. By comparing the concentration of the newly deposited green honey with that of the incoming nectar, as shown by the honeysac content of incoming bees, a measure was obtained of the increase in concentration which is attributable to the activities of house-bees in manipulating the nectar with their mouthparts prior to depositing it in the comb. These comparisons are shown in Table 1.

TABLE 1. INCREASE IN CONCENTRATION OF NECTAR BEFORE BEING DEPOSITED

Hour	Mean time in comb	Incoming nectar	"Green" honey soon after deposited	Increase
1 p.m.	30 min.	35.5%	55.8%	20.3%
2 p.m. ...	15	49.8	57.2	7.4
3 p.m.	15	42.8	61.0	18.2
4 p.m.	30	53.4	61.4	8.0
Average		45.1	58.8	13.5

It may be observed that the concentration found for the newly deposited green honey varied much less than that for incoming nectar and was not far from 60 per cent in any case. This may indicate that, regardless of its original concentration, the house-bee makes a practice of evaporating nectar down until its concentration is approximately 60 per cent before depositing it. Additional data will help to determine this

point. On the other hand, it may be that the uniformity of the incoming nectar really was greater than indicated. This might have been the case if the bees had been working on two or more sources producing nectars which differed considerably in sugar content, in which case more than 10 honeysacs should have been used in determining the concentration of incoming nectar. There is room for further refinement of technique as well as for additional data.

Altho too great reliance should not be placed upon the accuracy of individual values shown in Table 1, the averages should be fairly dependable and sufficiently representative to give a general idea of the effectiveness of this peculiar activity of house-bees in bringing about rapid evaporation of moisture from the nectar. The mean concentration of the incoming nectar recorded on this occasion is normal and typical for Iowa honey plants. It appears probable, therefore, that the mean increase of nearly 15 per cent shown in Table 1, may be fairly typical for Iowa honeyflow conditions.

Evaporation from the Comb. Data on the rate of evaporation of water from green honey in the comb was secured in the following manner. Comb 101 was returned to its place in the experimental colony at 4:25 p. m. on July 19, just 25 minutes after having been removed therefrom for the fourth and last time in connection with the preceding experiment. No further samples were taken until 7:30 p. m. This comb was returned to the hive again at dark and the bees were allowed free access to it during the night, but at 6:40 on the following morning, it was placed in a screen cage after all bees had been brushed from it and a sample taken. After being caged, Comb 101 was placed in the second story of Colony 712 between two combs of new honey.

During the afternoon of July 20, the same colony stored green honey in Comb 102 and on the following afternoon in Comb 103. No samples were taken from either of these combs until evening, after which the frame was caged and hung between partially ripe combs of honey in the second story of Colony 712.

Sugar determinations were made daily at about 10 a. m. until the honey in all three combs attained or surpassed a concentration of 80 per cent which was taken as the standard for ripe honey. Two samples, one from each side of the comb, were secured and the mean of these taken. Each sample was made up from the contents of 25 cells selected at random, but care was taken to see that all regions were about equally represented.

The concentration of incoming nectar was determined throughout the afternoons of July 19, 20 and 21 in the manner already described, and are

recorded in Table 2. It is to be noted that the averages for all three afternoons are almost identical. We may, therefore, consider the honey stored in Combs 101, 102 and 103 as having been produced from nectar containing 45 per cent sugar on the average.

TABLE 2. CONCENTRATION OF INCOMING NECTAR

Hour	July 19	July 20	July 21
1 p.m.	35.5%	45.0%	36.6%
2 p.m.	49.8	44.6	43.4
3 p.m.	42.8	47.9	46 4
4 p.m.	53.4	45.8	
5 p.m.			52.6
Average	45.4	45.8	44.5

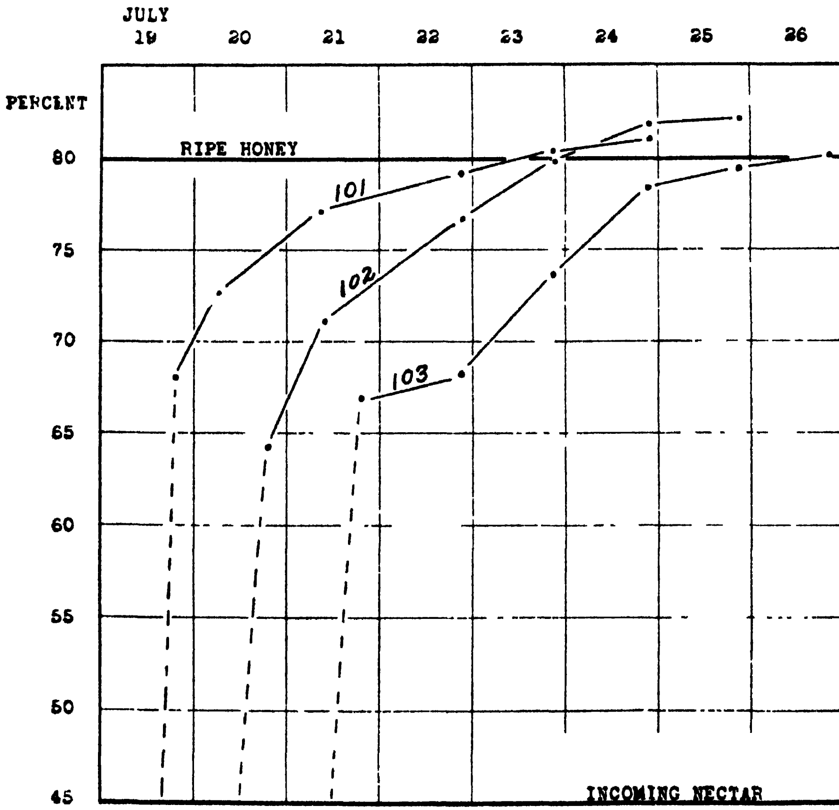


FIG. 14.—Rate of increase of sugar concentration during the honey-making process.

Fig. 14 is a graphic representation of the rate of increase in sugar concentration found during the honey making process.

Increases in concentration which occurred during the afternoon storage period are shown for each comb by the dotted portion of the curve. These dotted portions represent not only the effects of manipulation by house-bees before the nectar was deposited, but also a small amount of evaporation from the cells after deposition. The extent of the changes thus shown checks very satisfactorily with the results reported in the first part of this paper.

The fact that Comb 101 was not caged from the bees until early on the morning following the storage period seems to have made comparatively little difference. Combs 102 and 103 were both caged at the close of the storage period, but 102 gained in concentration faster than 101 during its first night, while 103 changed less than did 101. This is another point which will require further data.

The increase in concentration following storage was found to correspond closely with results[3] obtained several years ago from a somewhat similar experiment in which various concentrations of cane sugar solutions were used. Results obtained at that time from cells filled three-fourths full of a 60 per cent sugar solution, are almost identical with the present results obtained from green honey having an initial concentration of approximately 65 per cent, stored in the cells by the bees to varying depths which would average between one-half and three-fourths full. In both cases the concentration of ripe honey was reached after approximately three days within the hive but screened from the bees.

The rate of increase in these cases was due entirely to evaporation from the cells. There are reasons to believe that when bees have access to the combs as they do normally, they further hasten the evaporation of water by taking the green honey out of the cells and manipulating it as they do the fresh nectar. Manipulation by house-bees undoubtedly accounts for a very considerable part of the total water eliminated during the honey making process.

[3]Park, O. W. Further Studies on the Evaporation of Nectar. Jour. Econ. Ent., 21: 882-887. 1928.

EFFICIENCY AND ECONOMY IN APIARY INSPECTION

By R. G. Richmond, *Office of State Entomologist, Colorado Agricultural College, Fort Collins, Colorado*

Abstract

Describes a method of organization for apiary inspection suitable for present economic circumstances. This method has been applied in Colorado and in operation, is entirely satisfactory

Recently the Iowa State Apiarist's Report carried a friendly criticism of Apiary Inspection. The same report contained an answer in part by the writer to that criticism. It is a healthy sign that both of these articles come from the honey industry itself rather than from without.

It is not the writer's intent herewith to attempt to justify the expenditure of considerable sums of money annually for apiary inspection, but rather to point out economies and efficiencies which have been practiced with success. The justification for inspection, under present circumstances, is found in the constant demand, by beekeepers, for inspection. This demand has resulted in regulation or control rather than in the elimination of bee diseases.

In the meantime, while methods of eradication may be sought, the following plan of economy and efficiency is worthy of consideration and practice.

In Colorado, as elsewhere, it has been difficult to secure the most capable beekeepers to assist with inspection. Operating as we can to best advantage under a county inspection system, it has been well nigh impossible to secure the best minds as inspectors. They are too busy with their own affairs and the reimbursement, at times, has seemed inadequate. True, we have had excellent inspectors, but not always.

In order to interest the best talent possible, plans have been under way during the past four years. Various methods and combinations have been tried out, discarded or revised until a method of operation was evolved this season, promising not only efficiency but rather striking economy in cash outlay per colony for inspection.

The scheme bears the stamp of approval of leading commercial honey producers who have seen it in operation on the inspection of several thousand of their own colonies. With this procedure well organized, the cash cost per colony inspected should not be in excess of 3 to 4 cents under usual conditions in commercial apiaries and making a very liberal estimate.

The plan depends for its success on the cooperation of the beekeepers and the organization ability of the inspector. These two points are the

means to the end of reduction in cash outlay, by the county, for apiary inspection.

To illustrate the circumstances under which this scheme operated to advantage, 4200 colonies were inspected by one inspector in 10 days, 41 colonies had A. F. B., 21 were burned, 94 box hives were ordered transferred, 1100 miles were travelled to 84 apiaries consisting of from 1 to 108 colonies. Sixty-five of these apiaries might be termed commercial; the remainder were in the hands of farmer beekeepers

The most successful operation thus far achieved has been with a five-man inspection crew all working in the same apiary at the same time. Five to six hundred colonies may be inspected on one day of not longer than eight hours

THE PLAN OUTLINED For better understanding, let us number the members of the inspection crew 1, 2, 3, 4 and 5 Each number has his duty to perform

No. 1 removes the cover from the hive and if supers be present, removes them down to the brood nest and smokes the bees gently until they are under perfect control. He then proceeds to the next hive to do likewise At times he may be 2 or 3 colonies ahead of the next man, in which case the bees in previously-opened colonies should receive enough smoke to keep them below the top bars and well under control. (Usually No 1 is the only man needing a smoker He will need a good one with plenty of fuel able to produce great volumes of smoke.)

No. 2 removes the first brood frame from the hive and hands it to the inspector, who is No. 4. While the inspector is examining this frame, No. 2 removes the next frame from the hive, shakes the bees from it and exchanges it with the inspector This preparation of frames, their exchange and inspection goes on rapidly until all brood is inspected The inspector then turns to No 3

No. 3 has the same duties as No 2, but on alternate hives While No 2's colony is being inspected, No. 3 is preparing the next Nos 2 and 3 leave their colonies in the same condition as they found them.

No. 4, the inspector, receives the shaken frames from either No. 2 or 3, inspects the brood and returns the frame to the same person A one-legged stool is a great convenience to the inspector.

No. 5 does the reverse of No. 1, in that he re-establishes the colony as it was found by No. 1. (Sometimes he may need a smoker.)

ORGANIZATION OF PRODUCERS. As previously stated, the success of the plan depends in part on the beekeepers' cooperation. With the exception of the inspector the workers are voluntary aids who are owners of bees. No difficulty has been experienced thus far in securing this

assistance. Plans should be made to inspect about 500 colonies per day. Producers with that number or multiples of that number of colonies, in a community, should be invited to lend a hand for the day's inspection or for such time as is required. Sometimes owners wish to furnish all the help necessary. But, regardless of the source of aid, make plans for two or three days ahead so no time is wasted.

LABORATORY PRODUCTION OF CLUSTERS OF EUROPEAN CORN BORER EGGS FOR USE IN HAND INFESTATION OF CORN[1]

By L. H. PATCH, *Associate Entomologist*, and L. L. PEIRCE, *Agent, U. S Bureau of Entomology, Sandusky, Ohio*

ABSTRACT

To study the comparative effect of the European corn borer (*Pyrausta nubilalis*) in reducing the yield and quality of various strains and varieties of corn, it was found necessary that several different average borer populations or borer levels should infest each strain of corn. It was found necessary to produce, in the laboratory, clusters of corn-borer eggs with which to hand-infest the corn plants in order to obtain the levels of infestation desired. The most practical method developed for producing egg clusters in the laboratory was to place infested cornstalks in an emergence cage as a source of moths, to force the moths to lay their egg clusters on waxed paper suspended in specially designed oviposition cages, to cut from the waxed pape small disks, each bearing an egg cluster, and to pin these disks on common pins, which later are pinned on the corn leaves. A formula is presented for use in estimating the number of eggs which should be placed on each plant to obtain a definite number of mature borers. The estimated cost of producing the egg clusters was about 59 cents per 100 clusters for an experiment continued over a period of one year or 44 cents per 100 clusters when extended over three years.

With the realization of the potential danger of the European corn borer to our corn crop, it became desirable to know the amount of the damage in terms of the reduction in the yield and quality of grain which definite populations of the insect would cause and to find or breed strains of corn upon which the insect would cause the least damage. The solution of these problems required that different mean populations of the borers should infest the same field or strains of corn to be tested. The range in the mean borer population of groups of corn plants growing in different parts of a field was too slight under natural conditions for the purpose of the experiment. It was found impossible, also, to compare

[1]The authors wish to express their appreciation to W. H. Larrimer and D. J. Caffrey for making this work possible, to W. R. Walton for reviewing and correcting the original manuscript, and to G. W. Still for providing the photographs used in this paper.

the yields obtained with the borer populations of all the plants containing, for example, 1, 2, 3, or 4 borers per plant. The largest and most thrifty plants were found to favor the survival of their borer population and usually contained the most borers. Therefore, it was necessary to resort to the manual infestation of unit plots of corn to obtain the various desired levels of borer populations.

One of the first methods to be tried in obtaining the desired infestation of unit plots of corn was that of placing, within the unfolding leaves of the plants, egg clusters which were attached to sections of corn leaves. These were taken, when they were near the hatching stage, from corn plants upon which moths had been forced to lay large numbers of egg clusters by confining them in cages placed over the corn. Another method consisted in placing large cages over plots of corn in the experimental field. Corn-borer moths were kept within these cages until the desired number of eggs had been laid on the plants. Then the moths were killed and the cages were removed. Both of these methods proved unsuccessful. The partial desiccation of the sections of corn leaves bearing the eggs seriously affected the vitality of the hatching larvae when the first method was followed, and in the second method rain and windstorms killed many of the moths prematurely.

METHODS OF OBTAINING EGG CLUSTERS IN THE LABORATORY. The methods followed for obtaining clusters of corn-borer eggs in the laboratory have had for their object the efficient production of large numbers of eggs which would produce borer larvae having as much vitality and ability to survive on the corn plants as is possessed by the larvae hatching from eggs deposited under natural conditions in the field. In the fall the heavily infested plants of the preceding season's experiments are stripped of their leaves and then cut and bundled and taken to the emergence cage at the laboratory There they are shocked within the cage until spring, to protect the borers from being devoured by woodpeckers. In late spring they are placed in horizontal piles after the manner of stacking lumber. (Pl. 6, Fig. 1.) This method of piling provides an easy exit for the emerging moths. About 25,000 stalks of the larger stalked varieties of corn can be piled within a space 42 by 15 by 6 feet. The piles are soaked well with water from a hose to prevent them from drying out and the consequent dying or delayed emergence of many of the moths. Burlap covers, just large enough to cover the piles, are placed on top of the cage in such a way as to provide shade on hot days and to cause the moths to congregate in the unshaded parts of the cage, over the walks, where they are most easily collected.

The moths are collected most easily in the cool of the morning from 4.15 to 6 o'clock. Collections of 50 moths at a time were made in lantern globes when better means were not available. Each of these globes is provided with a linoleum cover at the small end and a cover of mosquito netting at the large end, the covers being held in place by elastic bands. A glass tube 7 inches long and seven-eights inch in diameter is inserted through a hole in the linoleum to project 3 inches into the globe. The exterior end of the tube is placed over the moth, which then flies into the globe.

An electric hair drier[2] with a celluloid-cone attachment (Pl. 6, Fig. 2) has been found efficient in collecting large numbers of moths. In operation, the celluloid cone is attached to the air intake of the drier by means of elastic bands and a flat metal disk which is soldered to the hair drier. The air current draws the moths into the cone through an opening at its apex, and a covering of copper-wire screening permanently attached to the base of the cone prevents them from being carried through the cone. Care is taken not to overcrowd the cone with moths.

The moths are placed directly in the oviposition cages. These consist of frames covered with 18-mesh copper-wire screen screwed together with the screened surfaces inside. (Pl. 7, Fig. 3.) The top of the cage is made up of 2-inch slats covered with screening, and provision is made for the admittance of the moths through a circular opening. Care is taken that the cage is entirely inclosed with screening; otherwise the moths would lay eggs on any available wooden surface and the resulting larvae would seriously interfere with the work. The imprisoned moths lay their eggs on sheets of paper suspended in the cage through narrow cracks, left for that purpose, between the slats in the cover. Waxed-paper sheets, 12 by 36 inches, offer several advantages not possessed by other paper. Cages 3 by 2 feet by 3 feet high conveniently hold 5,000 moths. The moths mate satisfactorily within the cages, and the 2,500 female moths in each cage laid an average of 8.45 egg clusters each, with an average of 25 eggs per cluster. The cages are placed in the laboratory rooms and are provided with a burlap cover, which is kept moist by water spray from a knapsack sprayer. The interiors of the cages are sprayed at intervals to provide water for the moths, but an excess of moisture causes unsanitary conditions at the bottom of the cage

[2]The hair drier with the cone attachment was provided through the kindness of D. W Jones and W. G. Bradley, European corn borer laboratory, Arlington, Mass. Mr Jones was also the first to use the type of oviposition cage hereinafter described, and to use waxed paper for obtaining the egg clusters laid by the moths.

where the dead moths collect. A cylindrical type of oviposition cage has been described by Briand.[3]

Each morning the waxed-paper sheets, bearing the eggs that were laid the night before, are taken from the oviposition cages. In removing the paper sheets care is taken that the eggs are not injured by the screening covering the slats. They are cut in two, making sheets 12 by 18 inches, in order to facilitate handling. It is preferable that the egg clusters be taken from the oviposition cages and removed from the sheets the same day and that the steps which are necessary before the clusters are ready to be placed on the plants be performed at that time. But this is not possible every day. The clusters are removed from the paper sheets by two separate operations, first with a leather punch and then with dissecting scissors with fine, sharp points. The paper is placed over a smooth block of maple wood. The punch is held over an egg cluster, which may be on either side of the paper, and is tapped with a hammer. The circular punch, with a nick previously made in its edge with a file, cuts a 10-mm. disk of paper with the egg cluster on it, but the disk remains attached to the sheet at the point where the nick prevented the cutting of the paper. All the clusters on the paper sheet are cut in this manner. The dissecting scissors are later used to sever the disks from the sheet.

The next steps provide proper conditions for the incubation of the eggs and an efficient means of placing the clusters on the plants in the field. The number of clusters to place on each plant is predetermined according to the methods to be described later. The determined number of clusters, on as many disks of paper, are all impaled on the point of a No. 4 common pin by sticking the pin successively through each disk near its circumference as far as possible away from the egg cluster. Then the pin is placed in a pinning block and all the disks are pushed from the point to the center of the pin. The pin is dropped into a straight-walled, flat-bottomed shell vial, 12.5 by 50 mm., which is held in a tray with a capacity of 225 vials. (Pl. 7, Fig. 4.) As the trays are filled, they are placed one above another with a double thickness of moist blotting paper between them and covering the tops of the vials. Care is taken that any surplus water from the blotting paper does not run into the vials. It is desirable, however, that beads of moisture should condense on the sides of the vials. The eggs may be kept under these conditions for 4 or 5 days at room temperatures (between 70° and 80°F.)

[3]Briand, L. J. Laboratory breeding of the European corn borer (*Pyrausta nubilalis* Hübn.) with special reference to equipment and cages Canad. Ent. (3) 61: 51–54, illus. 1929.

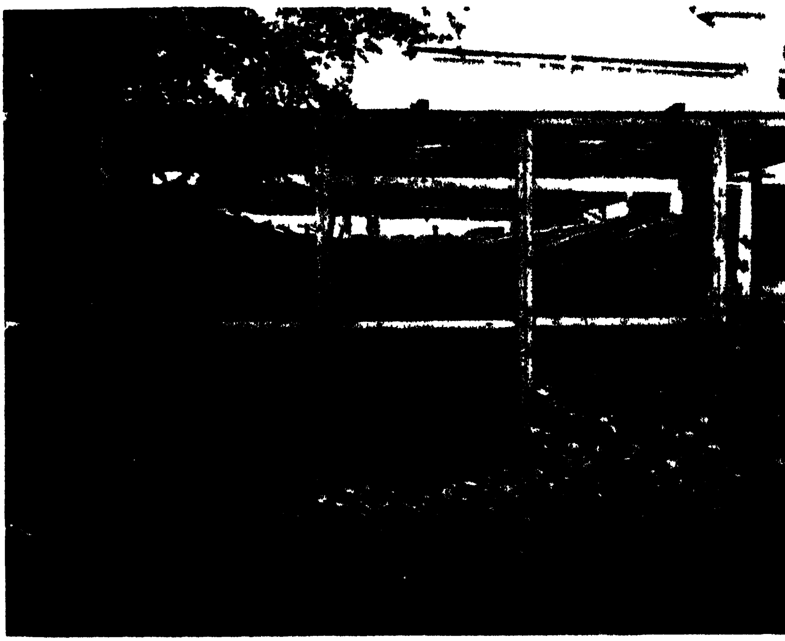
until they are nearly ready to hatch. If necessary, hatching can be retarded toward the end of the incubation period by placing the trays of eggs in a refrigerator at 50°F. for as long as 72 hours, without injury to the vitality of the resulting young borers. If it is found that the eggs hatch and the larvae crawl from the vials before they can be placed on the plants, cork stoppers should be put in the vials.

When it is not possible to remove the egg clusters from the waxed paper and perform the subsequent steps on the day they are taken from the oviposition cages, or if the steps can be performed as far as cutting the disks with the punch but not detaching the disks from the sheet with the dissecting scissors, the waxed paper, with its egg complement, can be placed between moist blotting paper until the subsequent steps can be performed. Alternate sheets of blotting paper and waxed paper, as many as 15 layers of each, can be placed on a tray without injury to the egg clusters. Each day's laying of clusters should be handled uniformly, however.

The mean number of eggs per cluster is determined by drawing samples of vials at random from the trays and by counting the numbers of eggs in the clusters with a binocular microscope by the aid of light reflected from an electric lamp through the waxed paper and the egg cluster. Counting is made easier by waiting until the embryos are plainly discernible in the eggs.

If enough egg clusters are being produced to infest an extensive area of corn and the problem of obtaining help to place the clusters on the plants is of vital consideration, a modification of the previously described methods is available. Instead of being put in shell vials, the pinned egg clusters are stuck upright as near together as possible on circular sections of cork 5½ inches in diameter and one-fourth inch thick. These sections of cork, with the egg clusters, are then placed one above the other in a glass battery jar 6 inches in diameter and 8 inches high, the bottom of which is covered with water, with care that the lower section is set above the water. The top of the jar is then covered tightly with several layers of moist blotting paper. (Pl. 7, Fig. 5.) When this method is used, it is important that the eggs do not hatch while in the jar and the larvae fall from the pins before the eggs are placed on the plants.

INFESTING CORN PLANTS WITH THE EGG CLUSTERS. The desiderata in the development of methods for infesting corn plants by hand have been the ease and quickness with which the clusters could be placed on the plants, the safety of the eggs from the time they are placed on the plants until they hatch, and a means of checking the number of eggs, if



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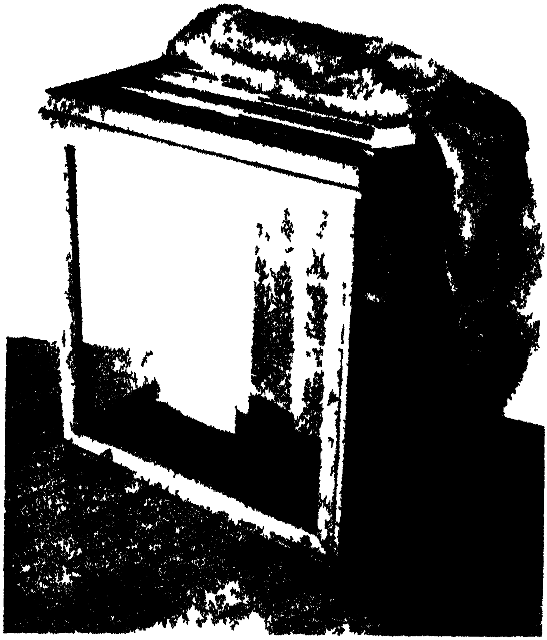
1.—Pile of infested cornstalks in an emergence cage from which European corn borer moths are collected. 2. Lantern globes and electric hair drier with cone attachment for collection of European corn borer moths.



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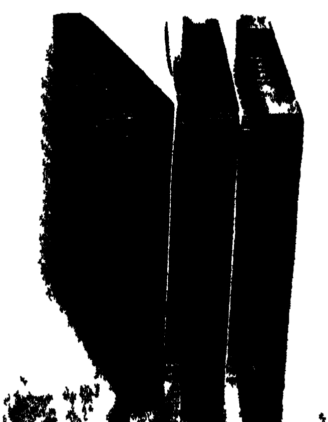

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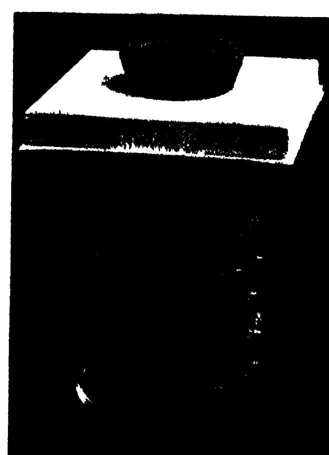

3.—Oviposition cage, 4—Tray and vials for incubation of eggs 5—Glass battery jar filled with cork sections bearing pinned egg clusters

any, that do not hatch. It is thought that these advantages have been realized with the use of the pins.

Unless the eggs have been incubated at a constant temperature, it is somewhat a matter of judgment just when they should be placed on the plants. If this is done just before the eggs hatch, the danger of injury by desiccation during the hot days of July will be minimized. To place the eggs on the plants, a piece of cork, bearing its numerous pins of egg clusters, is taken in the left hand. With the same hand one of the corn leaves, which comprises the whorl of leaves in the heart of the plant, is grasped and held steady, while with the other hand a pin is stuck through the midrib and as far down within the whorl as it is convenient to reach. In the same way one pin is placed in each of the other plants of the experiment. If the egg clusters and pins have been placed in the shell vials, and if the eggs have hatched and the young borers have become scattered in the vials, the cork stoppers should be removed carefully and a vial left within the unfolding leaves of each plant until the borers have crawled out onto the plant.

The proper number of eggs to place on each plant is determined from the number of mature borers desired. The percentage of eggs producing mature borers varies according to the borer density per plant. For instance, it has been determined from data obtained over a period of four years that, in a normal year, in the case of an average infestation of 30 borers per plant, about twice as many eggs must be placed on each plant as if an average infestation of 20 borers is desired.

TABLE 1. THE MEAN PERCENTAGE OF SURVIVAL OF LARVAE OF THE EUROPEAN CORN BORER HATCHING FROM EGGS PLACED BY HAND ON SEVERAL VARIETIES OF DENT CORN

Locality	Year	Plants in sample *Number*	Mean eggs per plant *Number*	Mature borers resulting *Number*	Survival *Per cent*
Sandusky	1931	288	10	2.02	20.2
Sandusky	1931	288	47	9.40	20.0
Toledo	1929	120	56	10.5	18.7
Toledo	1929	60	92	15 3	16.6
Sandusky	1931	288	91	16.4	18.0
Sandusky	1928	209	121	19.0	15.7
Toledo	1929	60	175	23.1	13.2
Sandusky	1928	213	179	24.7	13.8
Sandusky	1928	460	305	30 5	10.0
Toledo	1929	60	300	32 1	10.7
Sandusky	1928	234	435	37.0	8.5

During the three years 1928, 1929, and 1931, data were obtained at Sandusky and Toledo, Ohio, giving the mean percentage of survival of the borer on various varieties of dent corn. The corn was planted during the second week of May in each year. In Table 1 are given the

mean numbers of eggs and resulting mature borers which infested different samples of plants, and the percentages of survival of the borer computed therefrom.

It is noted from Table 1 that the percentage of survival of the borer decreased as the borer density per plant increased. The relation between the percentage of survival and the borer density may be expressed by a linear equation obtained by the method of least squares.[4] This equation is as follows:

$$z = 0.2252 - 0.00374y \text{ (Formula 1)}$$

where y is the mean number of borers per plant and z is the percentage of survival By substituting in the equation:

$$\text{Number of eggs} = \frac{\text{Number of borers}}{\text{Percentage of survival } (z)}$$

the number of eggs (x) needed to produce an approximate mean borer population (y) can be determined from the formula:

$$x = \frac{y}{0.2252 - 0.00374y} \text{ (Formula 2)}$$

The percentages of survival of the borer given in Table 1 appear to be the result of average optimum conditions of development for both the corn and the borer For equivalent borer densities the percentage of survival would vary according to the weather, the variety of corn, the fertility of the soil, and the date the corn was planted. During the drought of 1930 the survival of the borer was one-fifth of that in 1931. The survival of the borer on corn planted on soil receiving a heavy application of fertilizer has been as much as 1.75 times that on the corn planted in the same experiment on soil receiving no fertilizer In an experiment where mean borer densities of 2.0, 9.4, and 16.4 occurred in corn planted on May 8, the percentages of survival of the borer were 1.05, 1.22, and 1.43 times those on the corn planted on May 22 for the respective borer densities. With Formula 2, therefore, can be computed the number of eggs to be placed on dent corn to obtain the number of borers desired, when the corn is planted on fertile soil early in May and when the season is favorable for both the corn and the borer.

To determine if the borers hatching from the eggs obtained by the previously described methods had as much vitality and ability to survive on the corn plants as is possessed by the borers incubated under natural conditions, the percentages of survival of the borers incubated under the two conditions were compared. Plots of corn, 6 hills by 5 hills, were

[4]Mills, Frederick C. Statistical Methods, p 273–278. New York. 1924.

planted in triplicate for each of the two methods of incubation. The eggs incubated under natural conditions were taken from the corn plants on a section of leaf when they were about to hatch and were placed within the unfolding leaves of the plants in the experiment in the same manner and at the same time as were the eggs which were incubated in the laboratory. The survival of the borers hatching from the eggs incubated in the laboratory was 13.7 ± 0.52 per cent compared to 14.0 ± 0.50 per cent for the borers hatching from the eggs incubated under natural conditions. There was no significant difference between the two methods of incubation.

COSTS. The cost of infesting experimental plots of corn with the egg clusters of the European corn borer is given for use in estimating the cost of similar experiments which might be contemplated in the future. The items entering into the cost have been divided under three groups: (1) the cost of the equipment, which is an initial cost; (2) the cost of obtaining the infested stalks of corn as a source of supply for the moths, which is independent of the number of borers which the stalks might contain; and (3) the annual cost of the materials and labor, which is dependent on the number of egg clusters produced. The three classes of expenses have been reduced to the cost of producing 100 egg clusters, on the assumption that the labor is charged at 50 cents per hour.

The estimated initial cost of the equipment for producing approximately 250,000 egg clusters is as follows:

1	metal screen cage, 42 by 15 by 6 feet, with 4 burlap covers	$100.00
2	hair driers and 4 celluloid-cone attachments	23.50
15	lantern globes	1.50
10	oviposition cages, 3 by 3 by 2 feet, covered with copper screening	175.00
10	burlap covers for oviposition cages	13.00
1	knapsack sprayer	9.00
48	trays for holding shell vials	24.00
50	gross shell vials, 12.5 by 55 mm	25.00
12	glass battery jars, 6 inches diameter by 8 inches high	12.00
24	flat trays, 13 by 19 inches, wallboard	4.80
6	leather punches	2.10
12	maple blocks, 12 by 6 by 2 inches	3.60
4	hammers	2.80
1	ice box	20.00
30	gross cork stoppers to fit vials	5.00
100	feet rubber hose	8.00
8,000	cornstalks averaging 10 borers each	118.80
	Miscellaneous	10.00
	Total	$558.10
	Cost per 100 egg clusters	0.22324

The item for the 8,000 cornstalks is the cost of growing 1 acre of corn plus the cost of the egg clusters necessary to obtain 10 borers per stalk as

a source of the original supply of moths. After the first year the experiment would provide the stalks from which the moths could be obtained.

The estimated annual cost of obtaining 20,000 stalks as a source of moths is as follows:

Stripping leaves from the standing stalks	$76.50
Cutting the stalks and tying in bundles	43.50
Transporting the bundles 3 miles	7.00
Shocking the bundles in the cage	6.00
Piling the stalks in the cage	17.50
Watering piles before moth emergence	1.25
Total	$151.75
Cost per stalk	0.0075875
Assuming 5 moths per stalk and 4.225 egg clusters per moth, the cost per 100 clusters is	0.03592

The estimated annual cost of the materials and labor for producing 235,000 egg clusters is as follows:

Materials	
500 sheets of blotting paper, 12 by 18 inches	$11.50
2,000 sheets of waxed paper, 12 by 18 inches	3.68
25 pounds of No. 4 common pins	25.00
250 pounds of ice	3.00
Labor	
Supervision (on salary basis)	$125.00
Collecting moths from emergence cage	63.80
Care and tending of oviposition cages	55.00
Cutting out clusters from paper sheets, 600 clusters per hour	195.80
Pinning clusters, 375 pins per hour, on basis of 3 clusters per pin	104.50
Counting eggs per cluster, 20 samples of 100 clusters each	17.00
Pinning clusters on corn plants, 240 plants or pins per hour, assuming 3 clusters per pin	163.00
Total	$767.28
Cost per 100 egg clusters	0.32650

The estimated cost of producing 100 egg clusters is, therefore, 22.32 cents for the equipment, 3.59 cents for obtaining the stalks as a source of moths, and 32.65 cents for the materials and the labor to produce the egg clusters and place them on the plants, or a total of 58.56 cents. If the experiment is continued for three years, the cost of the equipment may be prorated over the period it is in use, and the total cost per year is 43.68 cents per 100 egg clusters. These costs do not include the laboratory quarters or the automobile equipment. The cost will vary according to the labor charge, the number of moths which are provided by the stalks, the number of clusters per moth, and the number of clusters that are placed on each corn plant.

PRELIMINARY REPORT ON CONTROLLING THE WINTER EMERGENCE OF THE JAPANESE BEETLE IN ROSE GREENHOUSES BY APPLICATION OF CHEMICALS TO THE SOIL

By F. W. METZGER,[1] *Associate Entomologist, Division of Japanese and Asiatic Beetle Research, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

The Japanese beetle (*Popillia japonica*) may cause injury in greenhouses containing roses by emerging during the winter months and feeding on the plants. This paper gives preliminary results obtained in an effort to control this injury by treating with various materials, beds containing five varieties of roses. As roses are usually allowed to remain in beds for a period of three to four years, final data on the value of the various tests will not be available until the expiration of that length of time.

During the winter of 1930–31 reports were received that the Japanese beetle was causing considerable injury in greenhouses during the winter months, particularly in February and March. This situation had previously been considered in connection with the activities of the Plant Quarantine and Control Administration[2], but no detailed study had been made of the injury caused by the adult beetles. The writer, therefore, visited some 50 of the larger greenhouses to determine the degree of such infestation and the amount of damage caused by the beetle. Those from which data were obtained included all the larger houses in the area heavily infested by the beetle, most of these being in Pennsylvania.

Roses were grown in 30 of these establishments and it was only where such plants were under cultivation that the beetle caused any appreciable injury. They appeared, however, to be considerable variation in the amount of damage caused by the insect even in the area heavily infested by the beetle, but 20 of the 30 rose growers reported that the beetles were sufficiently numerous to cause definite injury. The largest number of beetles collected in any greenhouse range during the winter 1929–30 was reported to have been approximately 64,000.

It was learned that many of the growers had inaugurated control measures, some of which appeared to have been satisfactory in preventing beetle injury.

It was believed, however, that a method could be developed whereby

[1]The writer desires to express his appreciatión of assistance rendered by Messrs. C. H. Hadley, W. E. Fleming, and A. R. Whitcraft.

[2]Stichter, G. B. Incidental Effects Following Certain Greenhouse Practices in Control of the Japanese Beetle. Proc. Penn. Acad. Science 2:58–60. 1928.

the beetle could be controlled by a soil treatment which would be cheaper and more effective than any of the practices previously employed.

TESTS TO DEVELOP A UNIFORM METHOD OF CONTROL The soil in rose houses is usually changed every three to four years It appeared, therefore, that a soil treatment applied when new soil was introduced, which would kill larvae present in it and also prevent the development of additional larvae during this period, would be of great value to the growers. Two varieties of roses, Dr. W. Van Fleet and Gardenia, have been grown successfully for three years in soil treated with lead arsenate maintained at concentrations of 1,000 to 2,000 pounds per acre mixed in to a depth of 3 inches No larvae were found after the first year in soil treated with lead arsenate at the 1,500-pound rate,[3] but no information was available regarding its effect on rose plants under glass or the quantity of material necessary to prevent larvae from developing for a three to four year period.

Tests to obtain these data were begun during the summer of 1931 and this paper presents the results obtained after one winter beetle season It must be remembered that the data are merely preliminary and are in no way a recommendation, as a practical treatment must be successful in preventing winter emergence for several years without injuring the plants in any way.

CONDITIONS UNDER WHICH THE TESTS WERE CONDUCTED

Because of the rather specific conditions found in rose culture under glass it was realized that experimental work, to be accurate, would have to be conducted in a greenhouse where roses were actually under cultivation, and a greenhouse at the laboratory was employed for this purpose

This house has inside dimensions of 17 by 32 feet with a door at each end. The top ventilators open from one side only, the south, and additional ventilation is provided by the opening of every other sash on both sides. Heat is provided by a bank of three pipes running along each side of the house.

To secure proper drainage, 10 inches of cinders was spread over the surface of the ground and the beds were constructed over this foundation. The side walls of the beds are of wood and are 9 inches high and the partitions between plots are of like dimension. The interior of the house is divided into eight plots 6 by 8 feet with a 1-foot walk in the center of each. In order to allow for the opening of the door at each end, the corner plots are somewhat smaller than those in the center. A plan of the house showing the arrangement of the plots is given in Figure 15.

[3]Fleming, W. E., and Baker, F. E., Unpublished results.

The beds were filled with 6 inches of soil from a field on which a crop of soybeans had been harrowed in, two weeks previously. This was

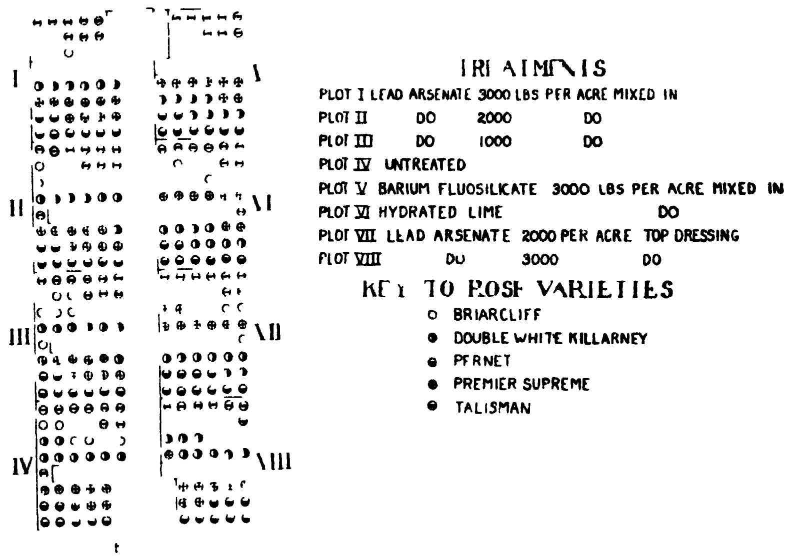

FIG. 15. Diagram of rose house showing arrangement of plants and treatments.

thoroughly mixed with well rotted manure at the rate of 1 part of manure to 7 parts of soil.

SOIL TREATMENTS

The eight plots in the house were treated as follows:

I. Lead arsenate at the rate of 3,000 pounds per acre mixed in 6 inches.
II. Lead arsenate at the rate of 2,000 pounds per acre mixed in 6 inches.
III. Lead arsenate at the rate of 1,000 pounds per acre mixed in 6 inches.
IV. Untreated.
V. Barium fluosilicate at the rate of 3,000 pounds per acre mixed in 6 inches.
VI. Hydrated lime at the rate of 3,000 pounds per acre. One fourth of amount mixed in soil August 14, and remainder applied in equal amounts October 1, November 1, and December 1.
VII. Lead arsenate at the rate of 2,000 pounds per acre applied as top dressing. One fourth of amount applied on August 14, and the remainder applied in equal amounts on August 21, August 28, and September 4.
VIII. Lead arsenate at the rate of 3,000 pounds per acre applied as a top dressing as in plot VII.

Several thousand beetles were collected shortly after August 1 and placed in tower cages over pots containing sand. Fifteen hundred eggs laid by these beetles were placed in each of the plots during the period

August 22–24. A test tray of 200 eggs indicated that a hatch of 75 per cent might be expected. Diggings made in limited areas of Plots IV and VI (both without poison) on October 5 failed to reveal any larvae. It was then decided to infest each plot with 500 freshly dug third-instar larvae and this was done during the period October 5–8

In order to determine from which plot the beetles emerged, screens were placed entirely around each plot after the first adult appeared, which was on February 4, 1932.

Rose Varieties Employed

Many varieties of rose are grown commercially in the Philadelphia area, but it was found that the varieties most generally under cultivation were Briarcliff, Double White Killarney, Premier Supreme, Souvenir de Claudius Pernut, and Talisman.[4] As the capacity of each plot was approximately 40 plants, it was not considered advisable to include additional varieties. This would have decreased the number of each variety in a given plot to such an extent as to render it difficult to determine the effect of the various treatments on the plants of a given variety.

The number and arrangement of the plants of each variety are shown in Figure 1, there being 69 Briarcliff, 60 Killarney, 68 Premier Supreme, 65 Pernet, and 68 Talisman, making a grand total of 330 plants

General Culture

As far as possible commercial greenhouse practices[5] have been followed in the cultivation of the plants. It was impossible to set out the plants until rather late in the season and, for this reason, it was impossible to get as good a selection as was desired. Killarney and Premier Supreme were severely injured by black spot in transit during a period of dull, humid weather and many of them never recovered from this set-back. Other plant diseases have been successfully controlled. Insect injury has been entirely prevented, but an infestation of the red spider has been very troublesome. Owing to extended periods of dull weather it was impossible to syringe the plants properly, and this prevented the proper control of this pest.

In general, growth was favorable up to the time the screens were placed over the beds, but since then, because of the amount of light cut off by the wire and frames, the plants have shown very little new growth.

[4]These plants as purchased were budded or grafted as follows: Briarcliff, Premier Supreme, and Killarney grafted on Manetti, Pernet budded on Odorata. Talisman was grown on its own roots.

[5]Holmes, Eber. Commercial Rose Culture, Fourth Edition. 242 pp., illus., 1930.

One of the greatest difficulties encountered has been the culture of five varieties of rose in one house, grouped together as they are in the various plots. Certain roses thrive on more heat than others, and the same is true of water requirements. It has been impossible to control these factors in a satisfactory manner under the conditions of this test.

More plants have died in Plots IV and VIII than in any of the other plots, owing chiefly to the fact that these plots have received considerably less sunshine than did the others.

Results of the Treatments. As far as can be determined at the present time, there has been no injury to the plants by any of the treatments with the possible exception of that of Plot VIII, where lead arsenate, applied at the rate of 3,000 pounds per acre, was used as a top dressing. The plants in this plot are somewhat smaller than those in Plot IV, which was untreated, but the difference in size is very slight.

Since the plants must remain in the treated soil for a three-year period, it is too early to make a definite statement regarding the effect of the various treatments, and the data given above can not be considered as final.

On Beetle Emergence

The first beetle emerged from Plot IV on February 4, 1932, but few additional individuals were found during that month or the first half of March and it was not until April 1 that beetles began to emerge in considerable numbers This is much later than usual and is accounted for by the fact that there were many dark days during November, December, and January which kept the temperature in the house between 70° and 75°F. and retarded larval development.

Table 1. Summary of Beetle Emergence from the Test Plots

Plot	Treatment	Total number of beetles emerging
I.	Lead arsenate, 3,000 pounds per acre mixed in 6 inches	1
II.	Lead arsenate, 2,000 pounds per acre mixed in 6 inches	2
III.	Lead arsenate, 1,000 pounds per acre mixed in 6 inches	7
IV.	Untreated	214
V.	Barium fluosilicate, 3,000 pounds per acre mixed in 6 inches	2
VI.	Hydrated lime, 3,000 pounds per acre top dressing	49
VII.	Lead arsenate, 2,000 pounds per acre top dressing	21
VIII.	Lead arsenate, 3,000 pounds per acre top dressing	18

The largest number of beetles emerged during April, and after May 1 only a few individuals were collected. The screens were finally removed on May 14, when several days had elapsed since any adults had been found. Diggings were made in the various plots and no larvae were

discovered, so the writer is reasonably certain that few, if any, remained in the beds.

A summary of the beetle emergence from the various plots is given in Table 1.

As indicated in Table 1, emergence in the untreated plot was 214 beetles, or 42.8 per cent of the total number of larvae placed in this section. In all plots where lead arsenate was mixed in the soil the number of beetles collected was so small as to be practically negligible, the emergence of 7 beetles in Plot III being but 3.3 per cent of those found in Plot IV which represents the largest number in any of the three sections mentioned above.

Lead arsenate and barium fluosilicate used at the 3,000-pound rate gave practically 100 per cent control, but as the latter material was used at only one concentration no comparison of the lower rates can be made

Hydrated lime reduced beetle emergence to 22.9 per cent of the check, but the number found in this plot would be sufficient to cause considerable damage.

Lead arsenate used as a top dressing at both the 2,000 and 3,000 pound rates reduced beetle emergence appreciably as compared with that in Plot IV, the decrease being 9.8 and 8.4 per cent respectively. It can be seen, however, that this method of applying the material is apparently much less effective than 1,000 pounds per acre mixed in 6 inches of soil.

Further data are necessary to determine the practical value of the treatments

LIFE HISTORY AND DISTRIBUTION OF THE LOW-TIDE BILLBUG, *CALENDRA SETIGER* (CHITTENDEN)

By A. F. SATTERTHWAIT[1], *Associate Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology, United States Department of Agriculture*[1]

ABSTRACT

This corn billbug breeds, so far as known, chiefly below high-tide mark in salt reed grass (*Spartina cynosuroides*) in maritime marshes along the Atlantic Coast.

[1]The writer wishes to acknowledge gratefully the assistance of Dr. W. H. Larrimer and others in the Bureau of Entomology in facilitating the work represented in this paper; of R. C. Lange in the labors of measuring and rearing specimens; of Miss Agnes Chase, in the U. S. Bureau of Plant Industry, and the staff of the Missouri Botanical Garden for determination of host plant; and of Henry Wenzel, whose generous donation to the author of a large number of specimens collected on Five Mile Beach, New Jersey, during the spring of 1915 pointed the way to a study of the life history of this species.

Reared indoors and in corn pith, larvae developed essentially in the same number of instars and in the same period of time as do species commonly attacking corn. A careful study of the immature stages indicates that the egg stage approximates 5 days, the larval stage 45 days for the six instar larvae and 51 days for the seven-instar larvae, and the pupal stage 10 days Measurements of eggs, head widths of larvae, and pronotal widths and total lengths of pupae have been recorded.

Beetles reared from eggs laid in captivity were healthy, wintered successfully, matured, and laid eggs from which a second generation of adults was reared.

This billbug's ability to adapt itself immediately to corn tissue, and to a complete absence of sea water, indicates its potentiality as a corn destroyer in the event that any soil land infested by it is directly converted to a cornfield In its larval and adult stages it is known to feed on salt reed grass, which is used to some extent as a wild hay

The investigation of corn billbugs and their control was assigned to the writer in 1915 He studied first the life histories of those species of the genus Calendra that are most generally distributed, but in 1926 he had an opportunity to extend these studies beyond the usual field of the North Central States, and he undertook to gather in New Jersey all the species of this genus not previously worked upon, including *Calendra setiger* (Chittenden) After finding colonies of this insect breeding below high tide, the writer anticipated difficulties in rearing its immature forms in the absence of two immersions of sea water daily, but he did not seriously consider the use of sea water artificially. The success experienced in rearing this species in sections of cornstalks gave further weight to the assumption, made early in this investigation, that all species of the corn billbug genus are potential corn destroyers.

Host Plants and Habitat. The collecting itinerary in New Jersey included stops at Westville, Gloucester, Woodbury, Anglesea, Sea Isle City, Avalon, Ocean City, Atlantic City, Asbury Park, Elberon, and again at Westville. At each station a careful search was made for eggs in all the grasses, sedges, and rushes of sufficient size to seem possibly suitable for oviposition. At Gloucester and Westville no evidence of the species was found. At Anglesea (Five Mile Beach) several adults that had recently died were found on the beach. A long, careful search disclosed three eggs in stems of salt reed grass (*Spartina cynosuroides*),[2] a coarse grass binding the sand dunes just above the breakers, ordinarily not covered by even the highest waves. A mass of grass stems and root stalks from the area where the three eggs were found was collected for use at the laboratory. One adult of *C. setiger* was reared from this collection of three eggs.

[2]This grass was determined by Miss Agnes Chase as the salt reed grass (*Spartina cynosuroides* (L.) Roth) from specimens taken near the U. S. Coast Guard station at Anglesea, N. J., June 22, 1926.

After this finding on the first day at Anglesea, further intense search was made for a better manifestation of the life habits of this insect, but not until the third day was a visit paid to the back bay. Here, at low tide, were found many living adults, as well as many eggs and larvae. These eggs and larvae were observed to be fixed in the grass and submergéd under several feet of water twice daily. The adults, of course, are free to move, but during periods of submergence they presumably cling to the plants in the zone of the eggs and larvae.

The host plant here was the same species as that first found growing on the beach. With this information as a lead to the preferred habitat of the species, additional specimens were found in Sea Isle City, Avalon, Ocean City, and Atlantic City on the tidal flats. At Asbury Park there was no back bay and no specimens of the low-tide billbug were found. No other host plant was found.

DISTRIBUTION. The distribution of the species, as determined from the examination of specimens by the writer, includes Connecticut, Florida, Illinois, Iowa, Louisiana, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island.

The writer has collected this species in New Jersey as follows: Anglesea June 22, 1926, eggs and newly-hatched larvae in *Spartina cynosuroides*, the species being verified by the rearing of one to the adult stage; 1 female, June 23, 1926, in a bed of *Typha angustifolia;* Avalon, June 25, 1926, 1 male and 1 female on grassy mound, and 1 male and 1 female in grassy area west of railroad; Ocean City, June 26, 1926, 2 males and 1 female in bay below high tide, 2 males and 1 female and some eggs in grass below high tide, 2 females at apex of knoll about 14 inches above high tide, and larvae in stems of *S. cynosuroides* (from these 11 adults were reared); Sea Isle City, June 24, 1926, 3 females under log on beach, 60 feet from grass; 17 adults were reared from *S. cynosuroides* from the flats back of the shore line.

In view of the conditions where these specimens were breeding, and of the known geographical distribution of this species, it seems improbable that the specimens which purported to be from Illinois and Iowa could have been correctly labeled. The specimen recorded from Pennsylvania might possibly be from "Philadelphia Neck." That from the interior of New York (Ithaca) might have been due to the introduction and establishment of a salt-marsh flora incidental to transportation of sand from the New Jersey coast for glass works or to the influence of salt mines in the vicinity of Ithaca.

Chittenden records (*2, p. 55*), with the original description of the species, specimens from Highlands, N. J., Ithaca, N. Y., Coney Island,

N. Y., Burlington, Vt., Virginia Beach, Va., Massachusetts, Maryland, and the District of Columbia, Pennsylvania, Iowa, Illinois, Texas, and other specimens recorded as from "N. J.," "N. Y.", and "Dakota." He later (*3, p. 148*) records his variety *intervallatus* as occurring at Anglesea, N. J., Plymouth and Woods Hole, Mass., in New York City and vicinity, and in Texas. Smith (*12, p. 397*) recorded *setiger* from Highlands, Lahaway, and Anglesea, N. J. Blatchley and Leng (*1, p. 557*) give distribution notes for *setiger* thus: "Common on salt meadows near New York City. Ranges from Vermont to Illinois and Dakota, south to Texas. Not recognized among the Indiana material at hand." Leng (*8, p. 336*) cites Vermont, Dakota, and Texas as representative sources. Concerning the distribution of this species in New York, Leng (*9, p. 513*) records the species from Ithaca, Dunwoodie, New York City, Staten Island, Long Island, Bellport, Coney Island, and the variety *intervallatus* from New York among type varieties.

Only one host plant, *Spartina cynosuroides*, is known to the writer. Lamson-Scribner (*6, p. 170*) states that this grass occurs on "river banks and lake shores, also brackish coast marshes, Maine and Nova Soctia to Assiniboia and Oregon, south to New Jersey, western Tennessee, Texas, and Colorado," and also (*7, p. 100*) that it is of a genus "chiefly maritime, or in the saline regions of the Great Plains." Mohr (*10, p. 128*) includes *S. cynosuroides* in a list of associated paludal plants (halophytes) in the open marshes in the tidewater district of Alabama.

In Gray's New Manual of Botany (*5, p. 143*) it is recorded as occurring in salt and brackish marshes, in Connecticut and southward. The distribution of this grass seems to correspond with the distribution of *C. setiger* as recorded in literature and in the collections. The abundance of the several stages of *setiger* found below high tide and the lack of abundance above high tide led the writer to believe that the occurrence elsewhere than below the high-tide mark was accidental and that records of the occurrence of the species in Vermont, Illinois, Iowa, and the Dakotas were the result of errors in labeling the specimens, and that its present establishment in these States is improbable. Each of these records appears to affect only one specimen.

EGG. The eggs of *C. setiger* are of the usual corn-billbug form but are more slender than those of congeneric species. Measurements of 245 eggs showed them to range in size from a minimum of 1.87 mm long by 0.62 wide to a maximum of 2.56 mm long by 0.91 wide. A collected egg, which subsequently yielded an adult of *C. setiger*, measured 2.34 mm long by 0.91 wide. Others, evidently the clutch laid by a single mother, were observed to vary in size without apparent consistency.

By summarizing the recorded measurements of 226 eggs originating from 13 mothers, the error in the following averages may be presumed to be very small The average measurements are 2.27 mm in length and 0.85 mm in thickness The average measurement of 50 eggs from one mother was 2.13 by 0 76 mm; of 13 eggs from another, 2 03 by 0.78 mm; and of 25 eggs from another, 2 42 by 0 85 mm Ratios of all measured eggs were determined individually The average ratio of length to thickness in 226 eggs is 2 67·1, with range from 2 03 1 to 3 39 1

The average duration of the egg stage appears to be about four days No egg under observation hatched in less than two days Frequently hatching occurred five days after deposition, and at least one egg is known to have required more than 8 1/3 days

These observations, although of eggs found in different years, represent identical seasonal periods The differences in duration of the egg stage appear to be attributable directly to less favorable temperatures in 1927 than in 1926

LARVA The larva is of the usual form for larvae of the genus Calendra With one exception, no difference is known by which the larva of this species can be distinguished from others of the same genus The Calendra larvae have, however, been distinguished from larvae of weevils of related genera by Cotton (*4, p 1-11*)

Table 1 gives the widths of heads of the several instars, on given numbers of specimens, regardless of age at which the individuals died or were killed but excluding measurements of every specimen the precise instar of which was doubtful

TABLE 1 SUMMARY OF MEASUREMENTS OF WIDTH OF HEAD OF LARVAE OF CALENDRA SETIGER IN EACH INSTAR

Instar	Specimens	Width of head		
		Average	Minimum	Maximum
	Number	*mm*	*mm*	*mm*
1. .	112	0.67	0 60	0 72
2	110	0.86	0.81	0.91
3. .	82	1.09	1.02	1.15
4	70	1.39	1 27	1.50
5	61	1.69	1.51	1.89
6	42	2 03	1.89	2.40
7.	23	2 28	2.09	2.45
8. .	2	2 35	2 30	2.41

About two-thirds of the larvae yielding healthy pupae or adults passed through seven instars, while about one-third had only six instars.

The average duration of the larval stage is approximately 48 days, 45 days for the larvae undergoing six instars and 51 for those having seven instars. All required more than 33 days, many are known to have required more than 43 days, and one more than 69 days, whereas one re-

quired less than 35 days and two less than 40 days The first several instars required about 5 days each, the next to last about 7 or 8 days, and the last about 15 days.

The habits of the larvae in the tide marshes were not studied, though they were found in excavations so like those made by other species in other host plants as to suggest no difference in manner of feeding.

In captivity the larvae fed upon and behaved in cornstalk pith as if this type of food was as acceptable to them as it appears to be to captive larvae of *Calendra maidis* (Chitt.), a species that normally inhabits corn.

The mature larva of *C. setiger* constructs a cell in a portion of the excavation, packing frass and coarsely shredded corn tissue so that the finished cell is just large enough for pupation One cell was 16 mm long and 6 mm in diameter, inside measurements The inside of the cell, including the walls and terminus of the larval excavation, is plastered with a coating about the thickness of coarse wrapping paper The plug used to partition off the cell from the rest of the feeding excavation was 7 mm in diameter and constructed of long, coarse fibers, loosely placed at the outer end and tightly packed next to the cell

PUPA. The pupa is of the usual color of species of this genus, being creamy white or ivory until after sclerotization has become visible The rostrum, femora, and margins of the dorsal parts of the thorax begin to show pigmentation first, then the antennae, tibiae, tarsi, and abdominal sternites, the rest of the body following fairly rapidly Usually at least two days elapse after pigmentation is apparent before the adult issues.

The rostrum has "only six seta-bearing tubercles, all conical, the basal pair set on broad, irregular prominences, high, deeply wrinkled, overhanging laterally," or appearing either as hemispheres cut under at the outer edge or columnar. Length, 11.70 to 14.36 mm; width of pronotum, 2.88 to 4.15 mm. (*11, p. 149*).

The average duration of the pupal stage was about 10½ days. One specimen passed through this stage in less than 7 1/6 days, while one required more than 15 days. The two extremes are, respectively, from the six-instar and the seven-instar series and of the same parent. The former was a pupa between September 14 and 21, the latter between October 14 and November 1. Presumably the low temperatures of the later season lengthened the period of the latter, but the temperatures of the laboratory in which the specimens were kept were not recorded.

ADULT. This species was described by Chittenden (*2, p. 55*) under the genus Sphenophorus. The differences in the adult stage between *Calendra setiger* var. *intervallata* (Chitt.) (*3, p. 148*) and *Calendra ludoviciana* (Chitt.) are very slight except that *ludoviciana* is, on the

average, much the larger species. The specimens on which Chittenden based his description of *setiger* have the even intervals of elytra less elevated than are those of *ludoviciana*. In *intervallata* "the first five intervals are long, wide, and subequally elevated, imparting to the variant an appearance very similar to that of *ludoviciana*."

When specimens of *C. setiger* var. *intervallata* and of *C. ludoviciana* can not be distinguished otherwise, differences will be found in the genitalia. In the males there appears to be a dependable difference in the exposed ends of the sternal plates of the eighth abdominal segment, those of *C. setiger* being very thick at the apical end, those of *C ludoviciana* lacking any appearance of thickness In the females of *C. setiger*, in the fork of the apodeme of the genital plate, the eighth sternite, the tines are curved at the base and the space between them is prominent, whereas in *C. ludoviciana* females the tines are straight and scarcely diverging.

Some adults, collected in June, 1926, remained alive till the late spring or summer of 1927. One female, collected in nature, deposited five eggs during the summer of 1926 and five eggs in June, 1927, and was dead by July 2, 1927. One reared female, issuing October 25–26, 1926, lived till September 11, 1927 One collected female established a laying record of 54 eggs.

Natural Controls Little or no effort has been made to determine the natural controls of this billbug However, the species was identified once by the U. S. Bureau of Biological Survey (unpublished note), when five specimens were found in the stomach of a laughing gull (*Larus atricilla*) taken at Cedar Island, Va., June 12, 1924

Economic Importance. This species of corn billbug has not yet attracted attention as an insect pest. Its potential importance, however, is indicated in the laboratory by the fact that it has been reared in cornstalk sections from adult to adult for two successive generations, through the same number of instars and in the same period of time normal for the most destructive corn billbugs, thus suggesting its ability readily to adapt its feeding to corn. It may not be generally realized that the cattail billbug (*Calendra pertinax* Oliv.), notorious for its frequent serious outbreaks in corn, almost or completely fails to adapt itself to cornstalk diet for the first generation. If any *setiger*-infested sod land containing *Spartina cynosuroides* or any other grass is converted to corn production without preliminary treatment, the corn is very likely to be destroyed.

Lamson-Scribner (*6, p. 179*) states that "when cut early this grass makes a fair but coarse hay, and it has been used successfully in the manufacture of twine and paper. The strong, creeping rootstocks

adapt it for binding loose sands and river banks, and in the West it is used for thatch." The host grass, therefore, is of some economic value, and therefore this insect can be considered as destructive in both the adult and the larval stages.

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SOME OBSERVATIONS ON *HYLOBIUS PALES* HERBST

By Harlan H. York, *Department of Botany, University of Pennsylvania*

ABSTRACT

Pales weevil work in stumps and at the root crown of pitch pine and white pine is recorded and described for several New York localities.

On July 3, 1931, the writer observed in the Warren County, New York, forest tree plantation of White Pine (*Pinus strobus*), which is located along the State highway between Glens Falls and Lake George, small localized areas where the branches of the White Pine to a height of four to five feet above the ground had been more or less scarred by the work of the Pales weevil (*Hylobius pales* Herbst). One tree, which was about three feet in height, had been so severely injured that the terminal portion of the leader had been killed (Plate 8, Figs. 1 and 2). This injury evidently had occurred sometime in the latter half of August, 1930, since the writer had been in this section of the planting on two different occasions, once about July 10th and again August 10th, 1930. Also this tree is in a plot where all of the trees have been under observation for the past three summers. Mention should be made of the fact, that the writer established this plot in July 1929 for observations on a pathological condition of some of the trees. At that time, and again in the summer of 1930 he noted here and there slight injuries similar to those caused by Pales weevil. The scoring on the tree in question was so conspicuous as to lead the writer to make a careful search for the possible breeding places of the weevil. Within about eight feet of this tree was the stump of a pitch pine (*Pinus rigida*) sapling, which had been cut off at the surface of the ground and which was between four and five inches in diameter. There were eighty-seven living sprouts on this stump ranging from about six inches to thirty-six inches in height, the tallest of which had two growth rings. The sapling pitch pine was cut in the spring of 1930. Some of the older sprouts had been lightly scored by the weevil. On removing the sprouts from the stump, considerable dried resin and resin-infiltrated soil were found. The weevil was pupating in the hard thickened crust of resin-infiltrated soil. In this material two tenereal specimens of Pales weevil were found. Three larvae, which were nearly twelve millimeters in length were observed in tunnels, in the region of the cambium of the stump three to four inches below the surface of the ground. The under side of the larger roots had also been infested to a distance of about six inches from their insertion on the root crown. Likewise the infestations ex-

1—Photograph of a white pine (*Pinus strobus* L.) tree which was about three feet in height and severely scarred by Pales weevil (*Hylobius pales* Herbst)

2

2—Portion of Figure 1 enlarged

tended almost beneath the root crown. Irritations produced by the larvae of the weevil may explain the development of so large a number of sprouts on this stump. When the sprouts were removed from another similar pitch pine stump, an adult Pales weevil was found in contact with the bark just beneath the duff, which consisted largely of pitch pine needles. Six other such stumps all of which had numerous sprouts and which had more or less an abundance of dried resin and resin in-filtered soil were examined No larvae and adult weevils were found. Pierson[1] has stated that the eggs of the Pales weevil are usually laid singly either in freshly cut pine logs or in the roots of fresh cut pine stumps. Judging from the nature and age of the callousing, it was evident that some of the root crowns had been infested for a period of three to four years, which means that the weevil had been present at least two to three years prior to the time when the saplings were cut The root crowns of three sapling pitch pine trees, three to four inches in diameter at the surface of the ground and which had been cut in the spring of 1930, one to two hundred feet from the area in question were examined. All were more or less resinous beneath the surface of the ground Two larvae, similar in all respects to those mentioned above were found in each of two of these saplings. Judging from the nature of the wound callous these trees had been infested for a period of at least three years. On August 29, 1931, the writer again visited the plantation and examined five stumps of sapling pitch pine, two to four inches in diameter at the ground, where the trees had been cut early in the summer of 1931 New sprouts, some of which were two to three inches in height were present on all of these stumps All of these stumps had been infested for a period of one to three years No larvae or adult weevils were found. At this time a sapling pitch pine, about two inches in diameter at the base, was removed from the ground. The under side of the root crown of this tree had been heavily infested with weevils. No larvae and adults were present

An occasional white pine tree in this plantation has been or is being killed by white pine blister rust. The stumps of two dead white pine trees, which were cut off near the ground early in the summer of 1931 were found to be infested. A larva similar to those taken from the pitch pine stumps and a tenereal specimen were found in cells in the resin in-filtered soil surrounding one of the white pine stumps. The dried masses of resin and resin in-filtrated soil about the stumps were not caused as the result of the blister rust infections, but were due to the wee-

[1]Pierson, H. B. The Life History and Control of the Pales Weevil (*Hylobius Pales*). Harvard Forest Bulletin No. 4. 1921.

vil, thus indicating the presence of the insects before the trees had died. Possibly the weevils may have hastened somewhat the death of the trees. Two white pine trees, between six and seven feet in height and which were completely girdled with stem cankers of blister rust within one foot of the ground, were within six to twelve feet of the stumps of the Pitch pine saplings which were cut early in the summer of 1931 and which were mentioned above. The root crown of one of these white pine trees on which the needles were quite yellow, had a considerable amount of dried resin and resin-in-filtered soil and had been quite heavily infested with weevils. The needles on the other tree were only slightly off color. This tree had apparently made an average height growth in the season of 1931. An adult female Pales weevil was puncturing the bark of the root between two and three inches below the surface of the ground. Ten healthy white pine trees in this same general vicinity were carefully examined. The soil was removed so as to see beneath the root crown. No weevils or traces of the same were found.

The association of the weevils was not surprising, since the writer had found in the latter part of June 1931, adults, larvae and pupae associated with the root crowns of trees of *Pinus resinosa* Ait which were quite heavily infected with *Armillaria mellea* near Peru, Clinton County, New York. He had also observed occasionally near Norwich and near Springwater, N. Y., in the latter part of July and the early part of August, larvae and adult weevils which were apparently Hylobius pales and which were associated with the resinous crowns of white pine trees which were about twenty years old and in forest tree plantations.

Mention should be made of the fact that the land at the time of the establishment of the Warren County forest tree plantation consisted of old abandoned fields and had no tree growth of any sort, with the possible exception of a few sapling pitch pine. The soil is a very light sandy loam.

In June of 1927 the writer called the attention of Dr. E. P. Felt, then State Entomologist for the State of New York, to a very severe weevil infestation in the crowns and roots of Scotch pine trees (*Pinus silvestris*) in a forest tree planting of this species near Ballston Spa., New York. Later in Bulletin 274 of the New York State Museum, 1928, in discussing this infestation, Dr. Felt states that "it" (Pales weevil) "appeared in a new role in a recent planting of Scotch pine some 15 years old at Ballston Spa." He seemed to be of the opinion that the behavior of Pales weevil in this plantation had been acquired in the presence of an exotic species. At this time the writer had not observed this insect attacking trees of the pitch pine which occur to the North and East

sides of the plantation. The writer observed in the summer and fall of 1927 infestations of the Pales weevil in plantations of Scotch pine near Lake Clear Junction and Paul Smith's, New York. In June of 1927 he caged stumps of infested trees of *Pinus silvestris* from the Ballston Spa., plantation in his office in the New York State Conservation Department, and secured within a week adults of *Hylobius pales* and *Pissodes approximatus*. The *Pissodes approximatus* were identified by Dr. H. J. MacAloney of the Northeastern Forestry Experiment Station. The specimens of adult weevils which the writer collected in the Warren County pine plantation near Peru and Norwich, N. Y., mentioned in the preceding paragraphs were similar to those which he compared with Dr. Felt's specimens. Furthermore they fit the description of *Hylobius pales* Herbst as given by Dr H B Pierson, Bulletin No. 3, Harvard Forest.

It is for these reasons that the adult weevils which the writer observed around the living stumps and root crowns of saplings of *Pinus rigida* and the dead stumps and root crowns of living *Pinus strobus* saplings infected with white pine blister rust, the root crowns of living *Pinus resinosus* and the root crowns of the *Pinus strobus* with an unknown disease, are believed to be *Hylobius pales* Herbst. In the light of these observations it seems that this weevil possesses a wider range of feeding habits than have been previously recognized

The observations discussed in this paper were made in connection with his work as Forest Pathologist in the New York Conservation Department.

RESULTS OF DUSTING EXPERIMENTS TO CONTROL THE BLUEBERRY MAGGOT

By L C McAlister, Jr., *Bureau of Entomology, U. S Department of Agriculture*

Abstract

In order to meet the standards established by the Food and Drug Administration of the U. S. Department of Agriculture, the production of maggot-free (*Rhagoletis pomonella*) blueberries for canning purposes in eastern Maine has become virtually a requisite. Experiments conducted during 1931 demonstrated that two applications of calcium arsenate will accomplish this under conditions of moderate infestation, although the insect may not be completely eradicated. Three applications of calcium arsenate will further reduce the maggot infestation, but there is increased danger of excessive arsenical residue. One application of calcium arsenate was found to be inadequate under ordinary circumstances. The calcium arsenate may be diluted with an equal quantity of hydrated lime and remain effective. Copper carbonate used as a dust in one field test reduced the number of maggots 97.11 per cent.

Preliminary experiments conducted by Lathrop and Nickels (*2*) during 1925 and 1926 indicated that calcium arsenate applied as a dust was a satisfactory control for the blueberry maggot (*Rhagoletis pomonella* Walsh), and that the low-bush blueberry plants were resistant to injury from calcium arsenate when applied in dust form. Results of investigations conducted during 1927 to 1929, inclusive, and reported by the same authors (*3*), demonstrated that the method of dusting with calcium arsenate could be recommended with confidence for the control of the blueberry maggot in eastern Maine.

A large proportion of the blueberries seriously infested with maggots in the vicinity of Cherryfield, Maine, were dusted with calcium arsenate during 1930 by the growers. In every case where the calcium arsenate was properly applied and correctly timed, a considerable degree of control was obtained. The reduction in the number of maggots infesting the blueberries obtained during 1930 as a result of these commercial applications of calcium arsenate was usually about 70 to 75 per cent.

This reduction in infestation is not sufficient, however, to enable the growers to meet the standards set up by the Food and Drug Administration of the U. S. Department of Agriculture under authority of the pure food laws. The production of maggot-free blueberries has now become virtually a requisite, and the viewpoint as to what constitutes satisfactory control of the blueberry maggot has been materially changed. The problem is further intensified by the fact that infested blueberries can not be culled out as they are being harvested. They escape notice until the berries are processed in the canning factory, and consequently a few maggots may render a large volume of blueberries unsatisfactory for canning purposes. During 1931, therefore, emphasis was placed on a study of methods by which the efficiency of the recommended control measures might be increased and at the same time poisonous residues might be avoided.

EMERGENCE OF FLIES. The time of emergence of the flies of the blueberry maggot during 1931 was little different from that noted during the period 1925 to 1929, inclusive (*3*), and was about 6 to 8 days later than that which occurred during 1930. In 1931 the first flies appeared in the emergence cages on June 22, and the peak of emergence was reached about July 10 or 11. The insecticides used in these experiments, therefore, were applied at the time previously recommended (*4*).

RESULTS OBTAINED WITH CALCIUM ARSENATE. Two applications of calcium arsenate have usually been sufficient to protect the blueberries

from maggots during most of the egg-laying period. On heavily infested land, however, this protection has not always been adequate. An experiment to determine the efficiency of three applications of calcium arsenate was run during 1931, and the results, together with those of dusting with one and two applications, are shown in Table 1. The infestation records are expressed throughout this paper as the number of maggots per No. 2 can (approximately 20 ounces of raw berries.)

TABLE 1. RESULTS OF ONE, TWO, AND THREE APPLICATIONS OF CALCIUM ARSENATE FOR THE CONTROL OF THE BLUEBERRY MAGGOT. CHERRYFIELD, ME., 1931

Plat No.	Size of plat Acres	Application Number	Date of application	Quantity per acre Pounds	Maggots per No. 2 can Check plat Number	Maggots per No. 2 can Dusted plat Number	Reduction in number of maggots Per cent
1	11.2	1	July 17	6.1	8.93±0.51	4.37±0.37	51.06±4.92
2A	14.7	2	July 13 July 20	5.8 6.0	9.00±1.34	0.72±0.21	92.00±2.44
2B	20.0	2	July 15 July 22	6.3 6.1	194.94±9.21	4.94±1.01	97.47±.52
3	8.5	3	July 2 July 13 July 20	6.1 5.8 6.2	9.00±1.34	0.22±0.04	97.56±.63

The control obtained from one application of calcium arsenate, as indicated by the number of maggots per No. 2 can, was not sufficient to meet the requirements that blueberries be essentially free of maggots. The results indicate, however, that under conditions of moderate infestation, as illustrated by Plat No. 2A, in which the normal infestation was 9 maggots per No. 2 can, two applications of calcium arsenate will satisfactorily control the blueberry maggot. This does not imply complete eradication of the insect, but rather a distinct subordination of the number of maggots as they affect the sale of the berries. On the other hand, the reduction of 97.47 per cent in the number of maggots obtained with two applications on Plat No. 2B, where the normal infestation was excessively great - 195 maggots per can--can not be considered adequate control. The treated berries could not be used in the canning factory because of the maggots present. Fortunately, only a small part of the blueberry land in Maine is so heavily infested. Under certain conditions where the initial infestation is excessively great, three applications of calcium arsenate may be needed to reduce the number of maggots to a sufficiently low point, although the difference in favor of three applications is slight. The blueberry plants in the plats under experimentation were not injured by the calcium arsenate.

RESULTS OBTAINED WITH CALCIUM ARSENATE DILUTED WITH HYDRATED LIME. During both 1929 and 1930 a mixture consisting of

calcium arsenate and hydrated lime in equal parts gave almost as great a percentage reduction in the number of maggots as did calcium arsenate used undiluted. Further to test the efficiency of calcium arsenate diluted with lime, the above mixture and a mixture consisting of one part calcium arsenate and three parts hydrated lime were used on field plats of blueberries during 1931. The results obtained from the use of these mixtures are shown in Table 2.

TABLE 2. RESULTS OF TWO APPLICATIONS OF MIXTURES OF CALCIUM ARSENATE AND HYDRATED LIME FOR THE CONTROL OF THE BLUEBERRY MAGGOT, CHERRYFIELD, ME., 1931

Plat No.	Material	Date of application	Quantity per acre	Maggots per No. 2 can Check plat	Maggots per No. 2 can Dusted plat	Reduction in number of maggots
			Pounds	*Number*	*Number*	*Per cent*
4	Calcium arsenate and lime in equal parts	July 15 July 22	6.0 6.4	7.65±0.64	0.67±0.15	91.24±2.09
5	Calcium arsenate 1 part and lime 3 parts	July 13 July 20	6.6 6.3	9.00±1.34	1.51± .33	83.22±4.44

The mixtures of calcium arsenate and hydrated lime used in the above tests were prepared by thoroughly mixing the correct proportions of each material so that the calcium arsenate and lime were distributed uniformly in the finished product.

In general, the mixture of calcium arsenate and hydrated lime in equal proportions was about as effective as calcium arsenate alone, giving 91.12 per cent reduction in the number of maggots, whereas undiluted calcium arsenate gave a reduction of 92 per cent in one experiment and 97.47 per cent in another during the same season. The mixture consisting of one part calcium arsenate and three parts hydrated lime gave 83.22 per cent reduction in the number of maggots, which, under the circumstances, would not be considered satisfactory control. This indicates that further dilution of calcium arsenate with more than 50 per cent lime decreases the effectiveness of the mixture so much that the use of such dilute mixtures should not be recommended for the control of the blueberry maggot.

ARSENICAL RESIDUE. The analyses of samples of blueberries taken from the dusted plats during the seasons of 1926, 1927, 1928, and 1929 show that in general the residue was not excessive at picking time when the dust was properly applied at the rate of 6 or 7 pounds per acre (*3*). The analyses indicate that there is little danger of excessive residue resulting from two applications of calcium arsenate, provided that the dusting is done in strict accordance with the recommendations, that the treatments are followed by normal rainfall, and that a period of at least two weeks intervenes between the last application of

dust and the harvest of the fruit (*4*). This conclusion is substantiated by analyses of samples of blueberries from experimental plats which had been dusted with calcium arsenate during 1931. Representative samples were picked with a blueberry rake from well-distributed points in the dusted areas, and the results of the analyses are shown in Table 3

TABLE 3 ARSENICAL RESIDUE ON BLUEBERRIES FROM DUSTED PLATS, CHERRYFIELD, ME., 1931

Plat No.	Material	Dust applied per acre *Pounds*	Applications of dust *Number*	Date sample was picked[1]	Time since last dust application *Days*	Residue of As_2O_3 per pound of berries[2] *Grain*
2A	Calcium arsenate	11.8	2	July 21	1	0.095
				Aug. 11	25	.008
3	Calcium arsenate	18.1	3	July 21	1	.143
				Aug. 14	25	.010
4	Calcium arsenate and lime in equal parts	12.4	2	July 23	1	.026
				Aug. 17	26	.005
				Aug. 17	26	.004

[1]Commercial harvest of the berries on the plats began on the following dates. Plat 2A and plat 3 August 14, plat 4, August 17

[2]The arsenical analyses were made by the Bureau of Chemistry and Soils

The results of the analyses made in 1931 indicate that the residue from two applications of calcium arsenate was considerably reduced by weathering during the period which intervened between the last dust application and the harvest of the fruit, and was not excessive at harvest. A total of 3.74 inches of rainfall distributed over 15 days occurred during the period July 21 to August 17. The arsenical residue remaining on the berries at harvest time after three applications, however, was equal to the International tolerance for arsenic, and three applications should not be used unless facilities for removing the residue are available. The residue remaining at harvest time on the berries which had been dusted with the mixture of equal parts of calcium arsenate and hydrated lime was slightly less than the residue resulting from two applications of undiluted calcium arsenate, which is in accord with the data obtained in 1929 (*3*)

SUBSTITUTES FOR CALCIUM ARSENATE. Copper carbonate has been prominent among possible substitutes for calcium arsenate in the control of the blueberry maggot because of its successful use in Florida (*5*) against the Mediterranean fruit fly (*Ceratitis capitata* Wied.), also a member of the family Trypetidae. During 1930 Chapman (*1*) used copper carbonate against the apple maggot in New York, and he reports that the results of his field test of this material against the apple maggot

were inconclusive because of an inadequate check plat. The codling-moth record taken in his experiment, however, indicated that copper carbonate was not effective against this insect.

During 1931 copper carbonate was applied as a dust to a lightly infested 4-acre field plat of blueberries at the rate of 6.8 pounds per acre for the first application on July 14 and 7.6 pounds per acre for the second application on July 22. The infestation of the blueberry maggot on this plat was reduced 97.11 per cent—from 7.65 maggots to 0.22 per No. 2 can.

The copper carbonate used in this field test was later found to be slightly contaminated with arsenic When the berries which had been dusted with the copper carbonate were inadvertently analyzed for arsenical residue, they were found to have a high arsenic content. When the copper carbonate itself was analyzed, it was found to contain 0.62 per cent arsenic trioxide, or 45 grains of arsenic trioxide per pound of copper carbonate.[1] Copper carbonate does not contain arsenic naturally, and it is not known how this material became contaminated. The quantity of arsenic contained in the copper carbonate used in this test is appreciable, but it is doubtful if it was enough to effect the results

SUMMARY. The production of maggot-free blueberries has become essential, and in 1931 emphasis was placed on a study of methods to increase the effectiveness of measures for controlling the blueberry maggot.

One application of calcium arsenate reduced the maggot infestation 51.08 per cent. Under ordinary circumstances this reduction would be much too low to meet the requirements It has been demonstrated that two applications of calcium arsenate, under conditions of moderate infestation, will satisfactorily control the blueberry maggot. This does not imply complete eradication of the insect, but rather a distinct subordination of the number of maggots as they affect the sale of the blueberries. Where the initial infestation is excessively high, three applications of calcium arsenate may be needed to reduce the maggot infestation satisfactorily. There is increased danger, however, of excessive arsenical residue resulting from three applications.

Two applications of a mixture consisting of equal parts of calcium arsenate and hydrated lime gave 91.12 per cent reduction in the number of maggots, and two applications of undiluted calcium arsenate gave a reduction of 92 per cent in one experiment and 97.47 in another. These results indicate that, in general, the mixture of calcium arsenate and hydrated lime in equal proportions is about as effective as calcium

[1]Analyses made by the Bureau of Chemistry and Soils

arsenate alone A mixture of 1 part of calcium arsenate and 3 parts of hydrated lime did not give satisfactory control of the blueberry maggot

Two applications of copper carbonate used as a dust reduced the number of maggots 97 11 per cent This is the result of one experiment, however, and should be confirmed by further tests

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TARTAR EMETIC AS A POISON FOR THE TOBACCO HORN WORM MOTHS, A PRELIMINARY REPORT

By J U Gilmore *Assistant Entomologist and* Joe Milam *Principal Scientific Aid Division of Truck Crop and Garden Insects United States Bureau of Entomology*

Abstract

Tests of forty materials during several seasons in an effort to discover an efficient stomach poison for the tobacco hornworm moths *Phlegethontius sexta* Joh and *P quinquemaculata* Haw have revealed that a 5 per cent solution of tartar emetic is an effective and satisfactory poison when used in conjunction with isoamyl salicylate as an attrahent Large scale field experiments have been conducted for three successive seasons with promising results The latest type of moth feeder developed is illustrated

For a number of years the efforts of the Clarksville Tenn laboratory of the Bureau of Entomology U S Department of Agriculture, in charge of A C Morgan[1] have been directed toward the discovery of a chemical attractive to the tobacco hornworm moths *Phlegethontius sexta* Joh and *P quinquemaculata* Haw The odorous principle of the bloom of Jimson weed (*Datura stramonium* L) which strongly attracts the moths to this plant, could not be isolated by distillation or by other methods employed However among the large number of aromatic oils and esters tested, three compounds were found having the desired

[1]Died July 28, 1931

reaction upon hornworm moths—namely, benzyl benzoate, isoamyl benzoate, and isoamyl salicylate.[2] Isoamyl salicylate, being the cheapest and most effective of the three, has been employed in nearly all subsequent experimental work. Large numbers of tobacco moths were captured when this material was exposed in trap cages[3] similar to enlarged house-fly traps Since these cages were expensive and necessitated daily attention for the removal of specimens and rebaiting, their use was of doubtful practical value Consequently, a search was made

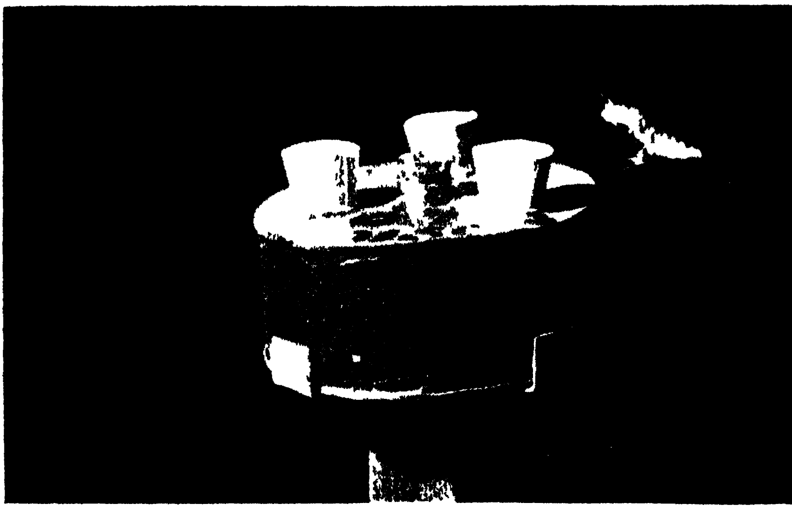

FIG. 16 A hornworm moth feeding at a poison feeder. (Flashlight photograph)

for a poison that could be used in conjunction with the isoamyl salicylate as an attractant, the bait to be exposed in especially constructed feeders.

LABORATORY TESTS OF VARIOUS POISONS The following materials were tested under laboratory conditions

Argentine ant poison,[4] barium chloride, boric acid, caffeine arsenate, carbolic acid, chloral hydrate, cobaltous arsenate, cobaltous chloride, cobaltous nitrate, cobalt oxide (powder, composition unknown), cobaltous sulphate, cobaltous ammonium sulphate, cobaltous chromate, cobaltous oxalate, cupric ammonium fluoride, cuprous potassium

[2]Morgan, A C., and Lyon, S. C. Notes on Amyl Salicylate as an Attrahent to the Tobacco Hornworm Moth. Jour. Econ. Ent. 21:189-191. 1928.

[3]Morgan, A. C., and Crumb, S. E. Notes on the Chemotropic Responses of Certain Insects. Jour. Econ. Ent. 21:913-920 1928.

[4]Active ingredient is sodium arsenite.

cyanide, cupric sulphate, formaldehyde 40 per cent, formaldehyde (dilute), formic acid, hyoscyamine hydrobromide, lead acetate, mercuric chloride, nicotine salicylate, nicotine sulphate, nitric acid, oxalic acid, paraffin oil, potassium aluminum sulphate, potassium arsenate, potassium arsenite, potassium fluoride, quassia chips infusion, sodium arsenate, sodium arsenite, sodium cyanide, sodium fluosilicate, strychnine arsenite, sulphuric acid, and tartar emetic.

Many of these substances were palatable to moths at certain aqueous dilutions, but either failed entirely to kill or were too slow in their toxic action. A generation ago farmers of Kentucky and Tennessee used a solution of some salt of cobalt in the Jimson blooms, and numbers of moths were reported killed, but under laboratory conditions no satisfactory kill was obtained with any cobalt compound.

Tartar emetic (potassium antimony tartrate) showed the most promising results under laboratory conditions. This poison, when dissolved in water sweetened with white sugar and placed in fresh Jimson blooms, was fed upon very readily by both species of hornworm moths. Individual moths were allowed to feed upon the sweetened tartar emetic solution for periods of time varying from one minute to five seconds, after which they were removed to another cage with unpoisoned Jimson blooms, where natural conditions were reproduced as far as possible. Practically all the moths that fed upon tartar emetic in these laboratory cage experiments died in less than 24 hours, many of them in about 15 hours. A 5 per cent solution was found to be effective.

FIELD EXPERIMENTS WITH TARTAR EMETIC Several field experiments were undertaken in 1928 as soon as the laboratory results on the lethal action of the tartar emetic were noted. Varying numbers of small funnels were closed with corks and mounted on stakes in the tobacco field. An ounce of poison solution was exposed in each funnel, and to each was attached a small bit of cloth heavily scented with isoamyl benzoate or isoamyl salicylate as an attractant. A sweetened 5 per cent tartar emetic solution was used in most instances, but in a few cases a 10 per cent solution was used.

The dead moths were collected and counted. After heavy feeding, moths usually flew to neighboring trees, where they remained until they died and fell to the ground during the night or early morning. Often a few sick moths could be dislodged by shaking the limbs of the trees. Other moths secreted themselves among the tobacco plants nearby and died there. On several occasions dead moths were collected 100 yards from the feeding point. Table 1 gives the number of dead moths recovered in the five experiments.

TABLE 1. NUMBER OF TOBACCO MOTHS KILLED BY POISONED BAITS CONTAINING TARTAR EMETIC IN 1928

(5 per cent tartar emetic used except where noted)

Date 1928	Experiment No. 1 Isoamyl salicylate, 38 bait containers		Experiment No 2 Isoamyl salicylate, 8 bait containers		Experiment No 3 Isoamyl benzoate 6 bait containers		Experiment No 4 Isoamyl salicylate, 12 bait containers		Experiment No. 5 Isoamyl Salicylate 4 bait containers		Total
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	
Aug. 11	*41	*41	—	—	—	—	—	—	—	—	
12	*10	*15	—	—	—	—	—	—	—	—	
13	* 4	*10	—	—	—	—	—	—	—	—	
14	*20	*25	*16	*16	—	—	28	20	7	10	
15	18	29	19	24	—	—	15	26	—	—	
16	23	22	3	2	7	11	—	—	—	—	
17	19	36	2	5	7	9	—	—	—	—	
18	2	3	5	5	2	4	—	—	—	—	
20	7	21	3	7	8	8	—	—	—	—	
21	8	25	0	6	5	6	—	—	—	—	
22	3	4	2	1	4	6	—	—	—	—	
23	10	12	4	8	5	10	—	—	—	—	
24	3	7	7	7	2	8	—	—	—	—	
27	1	6	2	1	1	1	—	—	—	—	
Total	169	256	63	82	41	63	43	46	7	10	780
Males											323
Females											457
Phlegethontius sexta											211
P. quinquemaculata											569

*10 per cent tartar emetic used

For comparative purposes several traps of the enlarged house-fly type containing the attractant were set out in the field and the number of moths collected during the period of the experiment was recorded. The total number of moths of both species caught in these traps was 1,872, of which 774 were females and 1,098 were males. The percentage of dead females recovered of those which fed upon the poison bait in the funnels was higher, being 58.59 per cent, than the percentage caught in the traps, which was 41.35 per cent This may have been due to the fact that the females were heavier, owing to their gravid condition, than were the males, and were thus unable to fly any great distance before being fatally affected.

During 1929, 1930, and 1931 large-scale field experiments were conducted wherein varying numbers of moth feeders were used per acre. The original single-funnel type of feeder was replaced in 1929 by a tri-funnel conical type, and in 1930 and 1931 still another type was used, as illustrated in Figure 16. This latest feeder consisted of a cylindrical container, in the top of which, were inserted three funnels which provided access to the poisoned sugar solution and a vial to contain the attractant. The container was 6 inches in diameter, 2½ inches deep and constructed of 26-gauge galvanized iron. The funnels of 30-gauge galvanized iron, were 3 inches long and 1½ inches in diameter at the top and the small ends reached within one-half inch of the bottom of the container. The vial, 1 inch in diameter and 3 inches long, was set in the center of the container. A lamp wick held in place by a tightly fitted cork extended into the attractant for the full length of the vial and protruded out of the vial an inch. This arrangement permitted gradual and slow evaporation. When exposed in the field the feeder was mounted by means of crossed metal clips on a 2 by 2 inch stake 4 feet high driven into the ground.

A 5 per cent tartar emetic solution was used as the poison in all three years. Practically all Jimson weeds in the area were destroyed each year, so that the moths were forced to the feeders.

The experiments were begun about July 1 each year and were continued until the tobacco was harvested, usually in September. The first year the moth feeders were spaced one-half mile apart over the entire 9 square miles. The next two years they were placed on elevations of 5 to 50 feet and near tobacco fields, singly or in groups of three and four. When the improved feeder was employed, visits were made every 10 days to 2 weeks for the purpose of adding water or refilling the vials containing the isoamyl salicylate. Once during the season the poison fluid was discarded and replaced with new material.

TABLE 2. SUMMARY OF FIELD EXPERIMENTS FOR CONTROL OF THE TOBACCO HORNWORM MOTHS IN 1929, 1930, AND 1931

Year	Area covered by tobacco in experiment	Total area covered by experiment	Feeders per acre	Total feeders used (in area)	Reduction in hornworm infestation (date and per cent)				Farms examined in area	Check farms examined
	Acres	*Square miles*	*Number*	*Number*					*Number*	*Number*
1929	360	9	1/9	39	Aug. 12—46.9	Aug. 22—56.4	———	———	10	10
1930	1,035	25	1/3	365	Aug. 5—77.0	Aug. 20—60.8	———	———	20	20
1931	1,142	25	1	1,008	Aug. 7—58.7	Aug. 13—70.0	Aug. 31—55.3	Sept. 17—31.0	20	20

The infestation of hornworms was carefully watched during the progress of the experiment, and as soon as the larvae were sufficiently numerous exact counts were made, both within and without the experimental area, and the relative numbers per 100 tobacco plants calculated. During 1930 and 1931, 20 fields were selected within the area and 20 fields were chosen at least one mile from the boundaries of the experiment. These selected fields within the area had, as nearly as possible, tobacco of the same size and tenderness or degree of maturity as the outside fields. Both groups should thus have been equally attractive to hornworm moths for oviposition. From the differences thus noted in larval counts the percentage of reduction in infestation due to the tartar emetic feeders was obtained.

Table 2 summarizes the results obtained in large-scale field experiments for the control of tobacco moths during the years 1929, 1930, and 1931 The hornworm infestations were light in both 1929 and 1930. In 1931 there was a heavier infestation than for several years. This should explain the lower percentage reductions obtained in most cases in 1931. It is believed that more than one feeder per acre should be used when there is a severe hornworm outbreak such as occurred in 1931.

BARIUM FLUOSILICATE AS A CONTROL FOR THE TOBACCO FLEA BEETLE

By F. S. Chamberlin, *U. S. Bureau of Entomology, Quincy, Fla.*

Abstract

Experiments with barium fluosilicate in the control of the tobacco flea beetle (*Epitrix parvula* Fab.) on shade-grown tobacco in Georgia and Florida are reported in this paper.

The tobacco flea beetle, *Epitrix parvula* Fab., is a major pest of cigar-wrapper tobacco in the Georgia and Florida producing areas and frequently causes severe losses. The method of controlling this pest by means of light applications of Paris green, which had been employed in the past, left much to be desired. When the weather was unfavorable severe burning of foliage often resulted and this became a matter of increasing importance on the newly introduced disease-resistant varieties of tobacco. Moreover, the moderate degree of control secured with light dosages of this arsenical necessitated the use of cleanup measures which are not easily applied under the present growing system. Although a large number of insecticides had been tried, no remedy

had been found which could entirely meet the exacting requirements of flea beetle control on cigar-wrapper tobacco.

PRELIMINARY EXPERIMENTS IN 1930. During the growing season of 1930 three of the newer fluorine compounds tested under laboratory conditions gave very promising kills, as shown in Table 1. In these tests the poisons were applied in the liquid form to small potted tobacco plants and the insects introduced. Preliminary tests in the field indicated that these compounds were much less injurious to tobacco foliage than Paris green and could be used at a greater strength with comparative safety.

TABLE 1. SUMMARY OF TESTS WITH ARSENICALS AND FLUORINE COMPOUNDS FOR TOBACCO FLEA BEETLE CONTROL IN 1930, INDICATING THE HIGHER TOXICITY OF THE LATTER COMPARED WITH THE FORMER

Insecticide	Total number of beetles	Per cent dead on second day	Per cent dead on sixth day
Potassium fluoaluminate (1–12)[1]	230	56.5	89.5
Barium fluosilicate (1–12)[1]	225	56.8	92.0
Barium fluosilicate and infusorial earth 80-20 (1–12)[1] ..	230	53.4	89.5
Synthetic cryolite (1–12)[1]	225	75.1	95.5
Lead arsenate (1–12)[1]	205	5.8	53.6
Paris green (1–50)[2]	330	32.7	76.9
Check	330	0.6	2.7

[1]One pound to 12 gallons of water.
[2]One pound to 50 gallons of water.

FIELD EXPERIMENTS IN 1931. Preliminary field experiments with synthetic cryolite and barium fluosilicate during 1931 showed that a satisfactory distribution of these materials on tobacco could not be obtained with the hand dusters available. The use of power dusters was eliminated, as they are not applicable under present conditions of tobacco culture under shade. Further tests showed, however, that a mixture of 80 per cent barium fluosilicate and 20 per cent finely divided infusorial earth could be applied fairly satisfactorily with a hand duster in which the material passed through a high-speed fan. A series of field experiments directed against the overwintered beetles on newly set tobacco was carried out with this material. Excellent control was obtained and no apparent burning resulted. Applications continued during the next three weeks likewise showed no foliage injury.

With the appearance of the second brood of beetles, a number of fields in the vicinity of Quincy, Fla., were found to be heavily attacked. The growers, knowing that applications of Paris green could not control these heavy infestations without severe foliage injury, assumed the risk of a partially tested poison and applied the diluted barium fluosilicate

on 25 shaded fields. Dosages averaged from 4 to 6 pounds per acre and in most instances a second application was made. Flea beetle control was estimated at 80 to 95 per cent and there were only slight traces of burning. A similar control effected with Paris green showed a loss of from 30 to 40 per cent due to burning of foliage. The rainfall and relative humidity for this period were far below normal and tobacco foliage was much less tender than is usually the case. For this reason the apparent value of results was rather questionable.

In several instances applications of the diluted barium fluosilicate were made only a few days prior to harvesting. This caused considerable apprehension that objectionable white residue might remain upon the cured leaves Light showers sufficed to remove the material from crops which had received an even distribution of the dust but a slight quantity of residue remained on crops which had received splotchy applications. Small-scale field experiments with undiluted barium fluosilicate indicated that an even distribution could not be obtained with this material and that the residue was only partially removed by light showers.

No other fluosilicates were tested in 1931 with the exception of the sodium compound This poison, even in a dilute form, caused such severe foliage injury as to make its use upon tobacco entirely impractical

Field Experiments in 1932 The results obtained with barium fluosilicate in 1931 were considered sufficiently favorable by the tobacco growers of the Quincy district to warrant its more extensive use the following season. The 28,000 pounds of diluted material used during the growing season of 1932 gave an excellent opportunity to observe its action when used on a commercial scale in the field.

Much trouble was experienced at the start owing to dampness of the poison, which caused clogging of dusters and uneven applications. Drying and mixing with various carriers remedied the situation to a considerable degree. An 8-acre field experiment carried out by the writer with diluted material gave evidence that a few thorough applications to newly set tobacco would eliminate most of the damage caused by the later broods. This conclusion was substantiated by several growers who followed the same method of procedure. The majority of the growers, unfortunately, delayed the early applications beyond the effective period and rather severe second and third brood infestations developed in many instances.

At the emergence period of the second brood of beetles during the latter part of May there occurred a seven-day interval of very wet, cloudy weather which caused tobacco to become unusually tender.

When dilute barium fluosilicate (80 per cent barium fluosilicate and 20 per cent infusorial earth) was applied to the foliage at the rate of 4 to 6 pounds per acre at this time a considerable amount of burning was caused, so this procedure was immediately discontinued. It was found, however, that burning could be largely eliminated by holding the nozzle of the dust gun in the center of the tobacco row and allowing the poison to drift onto the foliage. The safety of the drift method of dusting was increased by adding about 15 to 20 per cent by weight of finely-ground tobacco dust; this improved the feed action of the dusters and greatly increased the distribution of the poison Applications of from 4 to 8 pounds per acre of the poison mixture consisting of barium fluosilicate, infusorial earth, and tobacco dust in the proportions of 8-2-2, when properly made, left on the leaves an almost invisible film which caused practically no burning or residue trouble When the newly emerged beetles were concentrated on the lowest leaves of the plants, applications were most effective when the nozzle of the duster was directed toward the ground and in front of the operator. The dust cloud in this case did not rise sufficiently to cause discomfort to the operator. When the beetles were present over the higher portions of the plants, the nozzle was directed straight to the rear of the operator and upward at a slight angle. When large acreages were being treated in this manner the operators of the several dusters walked abreast in order to avoid the dust cloud Applications of this nature necessitated the use of dust guns with both front and rear outlets

While the drift method of application necessitated dosages of about 2 pounds more per acre than direct applications, it was found to be the only safe procedure to follow in high tobacco. Excellent control was obtained with dosages ranging from 4 to 8 pounds of the dilute material per acre, with, in most instances, two to three applications. A considerable portion of the kill appeared to be due to the fact that the dust particles adhered to the beetles' legs and antennae, which were subsequently cleaned by them. The greater part of the dust mixture, used commercially, consisted of barium fluosilicate, infusorial earth, and finely ground tobacco dust in the proportions of 8, 2, and 2, respectively. Field experiments performed by the writer indicated, however, that an 8-2 mixture of the poison and tobacco dust was somewhat preferable. Neither one of these mixtures caused commercial burning or residue trouble when properly applied.

CHLOROPICRIN AS A SOIL INSECTICIDE FOR WIREWORMS

By M. W. STONE and ROY E. CAMPBELL, *U. S. Bureau of Entomology, Alhambra, California*

ABSTRACT

Chloropicrin has been used considerably as a fumigant for warehouses and ships, but only infrequently as a soil fumigant. Experiments with this material in dilute solutions showed that it was toxic to wireworms, but its use on a large scale would be very expensive.

One of the gases used during the war, chloropicrin, has since found considerable use as a fumigant for various pests, particularly those of warehouses, ships, and stored grains. Roark's bibliography (1) and Gersdorff's supplement (2) list 367 titles, of which no less than 140 refer to the use of chloropicrin in the control of pests. In about a dozen of these the material was used as a soil fumigant against such pests as rodents, nematodes, and insects. Johnson and Godfrey (3) have a recent paper giving the details of an extensive series of experiments with chloropicrin on the control of nematodes on pineapples. The writers began a series of preliminary tests with this material as a soil insecticide in 1929 to find out its effect on wireworms [1]

The first experiment consisted in the use of a very dilute solution of 1 ml chloropicrin to 3 liters of water, added to flowerpots 10 inches in diameter and 10 inches deep, containing soil with live wireworms. One liter of this solution, applied to the surface of the soil in the pot and allowed to soak in, gave a 20 to 50 per cent kill, while 2 liters killed 75 per cent.

On account of the fact that chloropicrin is only slightly soluble in water (4), and to facilitate its handling, an emulsion was made using equal parts of chloropicrin and fish-oil soap. Vigorous shaking for a short time made a satisfactory emulsion. One ml of such an emulsion, applied with 1 liter of water to the 10-inch pots, killed only 5 per cent of the worms, but 2 ml or more killed 100 per cent.

As these preliminary experiments quite definitely showed that chloropicrin in dilute solution was toxic to wireworms, further and more extensive tests were planned. In the following group of tests a galvanized iron vat, 3 feet square and 1½ feet deep, containing soil from a typical wireworm-infested field was used. The soil in this and all future experiments was sandy loam and contained from 10 to 15 per cent of moisture. Small wire screen cages, 1 inch in diameter and 10 inches long, each containing soil and wireworms were placed horizontally at various

[1]The species concerned was *Limonius californicus* Mann.

TABLE 1. EFFECT OF CHLOROPICRIN ON WIREWORMS IN SCREEN CAGES PLACED IN 3-FOOT-SQUARE VAT OF SOIL. SOLUTION PLACED IN 9 EQUIDISTANT HOLES 4 INCHES DEEP

Solution used	Water added	Depth of cages in soil: 4 inches, Dead		4 inches, Alive	8 inches, Dead		8 inches, Alive	12 inches, Dead		12 inches, Alive
	Gallons	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*
20 ml chloropicrin, 20 ml soap, and 140 ml water	0	40	100	0	37	97.4	1	18	47.4	20
20 ml chloropicrin, 20 ml soap, and 140 ml water	6	21	55.3	17	29	74.4	10	12	30.8	27
Checks	–	0	0	10	1	10	9	0	0	8

TABLE 2. EFFECT OF CHLOROPICRIN ON WIREWORMS WHEN THE EMULSION WAS ADDED TO WATER AND THE SOLUTION APPLIED TO THE SURFACE OF SOIL IN A 3-FOOT-SQUARE VAT

Experiment No.	Chloropicrin used	Soap used	Water used	Depth of cages containing wireworms: 2 inches, Dead		2 inches, Alive	6 inches, Dead		6 inches, Alive	8 inches, Dead		8 inches, Alive	12 inches, Dead		12 inches, Alive	Remarks
	Ml	*Ml*	*Gals.*	*No.*	%	*No.*	*No.*	%	*No.*	*No.*	%	*No.*	*No.*	%	*No.*	
1	15	10	6	39	78	11	28	58.3	20	10	20.8	38	11	22.0	39	Soil not packed
2	20	20	5	50	100	0	50	100	0	36	72	14	4	8	36	Soil evenly packed

depths in the vat, and the soil was firmly packed so that its physical condition was uniform throughout. An emulsion was made of 20 ml of chloropicrin and 20 ml of soap and added to 140 ml of water. Twenty ml of this was poured in each of nine holes 4 inches deep made equidistant over the surface, but none of them directly over a wireworm cage. After the liquid was poured in, the holes were covered up with soil. In one experiment 6 gallons of water were then added to the surface of the soil, in another no water was added. Where no water was added the kill was 100 per cent at the 4-inch level, 97 per cent at 8 inches, and 47 per cent at 12 inches (Table 1); but where water was added, the killing was considerably less at all depths The greatest decrease was at 4 inches, which was due to the fact that with the solution placed in holes 4 inches deep and the water added, there was a tendency for the water to carry the chloropicrin too deep for it to be effective in the upper layers of soil.

Since a large part of the wireworm-infested soil in southern California is irrigated land, the writers believed that if a toxic agent could be added to the water at the time it was run onto the land, a cheap and efficient method of application and spreading would be available. Accordingly experiments were carried out by placing the chloropicrin emulsion in water, applying the solution to the surface of the soil, and allowing it to soak in The same 3 by 3 foot vats were used In experiment 1 (Table 2) the soil was shoveled into the vat and not packed at all. Consequently the liquid penetrated the soil unevenly, which accounts for the unevenness of the kill In experiment 2 the soil was firmly packed in all parts of the vat, and the solution penetrated the soil evenly. One hundred per cent of the worms were killed at 2 and 6 inches, with 72 per cent and 46 per cent at 8 and 12 inches, respectively

The experiments were continued with the additional results shown in Table 3. In each of these experiments the same quantity of chloropicrin was used, but the quantity of water varied. As the solution was applied to the surface of the soil and allowed to soak in, the surface layers were saturated. The quantity of the solution reaching the lower depths of the soil became progressively less until that level was reached beyond which the solution did not penetrate. The 6-gallon application is the equivalent of 1.07 inches of rain and penetrated the soil to about the 12-inch level. Eight gallons equals 1.43 inches, and penetrated to about 15 inches. In all experiments in this set there was a 100 per cent kill at the 4-inch depth, but at the 8 and 12 inch levels there was a higher percentage of mortality with the larger quantity of water

An attempt was also made to apply the chloropicrin without first emulsifying it. An excess of chloropicrin was placed in the bottom of a

large U tube and the water run through the tube and onto the soil. In this way a small quantity of the chloropicrin was dissolved as the water passed through it A variation in the quantities used was obtained by varying the speed with which the water ran through it On several occasions the water ran through so fast that drops of undissolved chloropicrin were carried along In general the results, as shown in Table 4, were not so satisfactory as where an emulsion was used Some of the undissolved chloropicrin remained on the surface of the soil after the water had sunk in, and was lost by evaporation

TABLE 3. EFFECT ON WIREWORMS OF AN EMULSION OF EQUAL QUANTITIES OF CHLOROPICRIN AND SOAP IN 6 AND 8 GALLONS OF WATER APPLIED TO A VAT OF SOIL 3 FEET SQUARE, 1929

			Depth of cages containing wireworms					
	Chloropicrin	Water	4 inches		8 inches		12 inches	
Date	used	Used	Dead	Alive	Dead	Alive	Dead	Alive
	Ml	*Gallons*						
Aug. 29	20	6	40	0	14	24	2	10
Aug. 15	20	6	40	0	21	19	13	24
Aug. 25	20	6	40	0	21	19	18	22
Total			120	0	56	62	33	74
Average kill			100%		47.4%		30.8%	
Aug. 9	20	8	38	0	31	8	31	9
Aug. 5	20	8	39	0	18	20	1	39
July 26	20	8	39	0	15	22	10	26
Total			116	0	64	50	42	74
Average kill			100%		56.1%		36.2%	
Checks			1	19	0	19	2	17

All the foregoing experiments were carried on in pots or the 3-foot square tanks. Additional tests were made in measured portions of a typical wireworm-infested field, in which the screen-wire cages had previously been buried at given depths throughout the plot The soil around the cages was packed so that its physical condition was the same as that of the rest of the plot It was then irrigated in furrows with the chloropicrin solution An emulsion was made of equal parts of chloropicrin and fish-oil soap, and this was added to the stream of water as it entered the plot. Examinations made three and five days later confirmed the results obtained in laboratory tests, as is shown in Table 5 A 100 per cent kill was obtained at the 4-inch depth, but as the solution descended and the quantity in the soil became less the killing decreased accordingly.

As a comparison, an emulsion of carbon disulphide of the same strength was applied in the same manner to a plot of the same size, with the wireworm cages in the soil and physical conditions the same as in the chloropicrin plots. As is also shown in Table 5, carbon disulphide was

TABLE 4. RESULTS OF THE APPLICATION OF CHLOROPICRIN IN WATER, APPLIED TO SOIL IN A VAT 3 FEET SQUARE, 1929

Date	Chloropicrin used	Water used	Depth of wireworms in cages: 4 inches, Dead		4 inches, Alive	8 inches, Dead		8 inches, Alive	12 inches, Dead		12 inches, Alive
	Ml	*Gallons*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*
August 30	4	6	3	10	27	0	0	30	0	0	30
September 11	5	6	13	65	7	4	20	16	2	10	18
September 5	10	6	20	100	0	7	35	13	0	0	20
September 6	18	6	40	100	0	5	12.5	35	1	2.6	37
September 7	34	6	19	82.6	4	4	20	16	1	5	19
October 13	25	8	20	100	0	11	55	9	3	15	17
Checks	--	-	1	5	19	0	0	20	0	0	20

TABLE 5. RESULTS OF FIELD TESTS WITH CHLOROPICRIN COMPARED WITH CARBON DISULPHIDE EMULSION APPLIED IN IRRIGATION WATER TO PLOTS OF 150 SQUARE FEET, 1929

Date	Chemical	Quantity of of chemical	Water	Depth of wireworms in cages: 4 inches, Dead		4 inches, Alive	8 inches, Dead		8 inches, Alive	12 inches, Dead		12 inches, Alive
		Ml	*Gallons*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*
August 12	Chloropicrin	332	100	70	100	0	49	73.1	18	38	61.3	24
August 27	Chloropicrin	662	200	34	100	0	31	91.2	3	27	81.8	6
Totals				104	100	0	80	79.2	21	65	68.4	30
Checks				0	0	14	0	0	23	0	0	23
August 26	Carbon disulphide	332	100	6	9.8	55	3	5.5	52	6	12.2	43

very much less effective than the chloropicrin Further comparisons were made with carbon disulphide emulsion in which measured quantities of this material were added to the 10-inch flowerpots containing wireworms As is shown in Table 6 it required 6 ml of carbon disulphide before any killing was obtained even at the 4 inch level while 2 ml of chloropicrin emulsified and added with 1 liter of water had given 100 per cent kill as previously reported

TABLE 6 EFFECT OF AN EMULSION MADE OF EQUAL PARTS OF CARBON DISULPHIDE AND FISH OIL SOAP ON WIREWORMS IN FLOWERPOTS 10 INCHES IN DIAMETER AT TOP AND 10 INCHES DEEP

Dosage (Ml)		Depth of cages containing wireworms 4 inches		8 inches	
Carbon disulphide	Water	Dead *Number*	Alive *Number*	Dead *Number*	Alive *Number*
3	400	0	4	0	4
3	500	0	4	0	4
4	400	0	4	0	4
4	500	0	4	0	4
5	400	0	4	0	4
5	500	0	4	0	4
6	200	0	8	0	8
6	300	4	4	1	7
6	400	0	12	0	12
6	500	8	0	6	2
6	500	0	4	0	4

A final comparative test was made using liquid hydrocyanic acid As this is soluble in water the various quantities used were added directly to the water and the solution was run onto the soil in the 3 by 3-foot vats Soil conditions were similar to those in the previous experiments with chloropicrin and carbon disulphide The hydrocyanic acid did not kill quite so high a percentage of wireworms as did the chloropicrin owing probably to the fact that this liquid is so highly volatile that much of it is lost by evaporation In the last two trials

TABLE 7 EFFECT ON WIREWORMS OF LIQUID HYDROCYANIC ACID ADDED TO A VAT 3 FEET SQUARE

Liquid hydrocyanic acid	Water used	Depth of traps containing wireworms 4 inches			8 inches			12 inches		
		Dead		Alive	Dead		Alive	Dead		Alive
Ml	*Gallons*	*No*	%	*No*	*No*	%	*No*	*No*	%	*No*
10	5	3	15	17	0	0	19	0	0	19
15	5	10	50	10	1	5 5	17	0	0	19
20	6	8	72 7	3	0	0	10	0	0	10
20	7	5	50	5	0	0	10	0	0	10
20	6	2	22	7	0	0	10	1	10	9
20	6	7	35	13	1	5	19	1	5 5	17
25	6	7	70	3	1	10	9	0	0	10
25	6	11	55	9	2	10	18	0	0	20
20	6[1]	14	61	9	5	23	17	15	79	4
15	6[1]	10	50	10	2	11	17	22	100	0

[1]Additional water resulted from heavy rain

as listed in Table 7, the material has been applied just as in the others, but during the following night rain water ran into the vats till an inch or more was standing on the surface in the morning. The higher kill at the 12-inch depth would seem to indicate that the excess water carried the hydrocyanic acid to the lower levels

As applied in Tables 1, 3, and 5 it would require 25.6 gallons of chloropicrin per acre for field work. In experiments where less than this quantity was used, many of them unrecorded in this paper, the percentage of dead worms was mostly too low to be considered satisfactory. Since 1 gallon of the chemical weighs about 13 pounds, and the price has been quoted at from $0 65 to $1 00 per pound, it is obvious that, although chloropicrin proved toxic to wireworms in dilute solutions, its use in field control would be expensive and not practical except for very valuable crops. A few trials with germinating seed and young plants indicated that the dilute solutions as used were not injurious to them, which suggests the possibility of using this material as a soil insecticide in nurseries, gardens, and such places

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FIELD EXPERIMENTS WITH VARIOUS POISON BAITS AGAINST WIREWORMS, *LIMONIUS (PHELETES) CANUS* LEC.[1,2]

By Russell S. Lehman, *Assistant Entomologist, Division of Truck Crop and Garden Insects, United States Bureau of Entomology*

Abstract

Approximately 125 organic and inorganic compounds were employed at different concentrations in ground whole-wheat baits to determine their effect on wireworms, *Limonius (Pheletes) canus* L. Arsenic compounds were found to be definitely repel-

[1]Order Coleoptera, family Elateridae.

[2]All the experimental work for this investigation was conducted at the U. S. Bureau of Entomology laboratory located at Walla Walla, Wash., M. C. Lane in charge.

TABLE 1. DATA SHOWING TOXICITY OF VARIOUS INORGANIC COMPOUNDS WHEN USED IN BAITS FOR THE CONTROL OF WIREWORMS

	Poison baits							Control baits			
Compound	Concentration per bait, in grams	Total number of baits	Total number of larvae	Average per bait	Days in soil	No. dead when examined 1 week later	Per cent killed	Total number of baits	Total number of larvae	Average per bait	Days in soil
Aluminum borate[1] (C. P.)	1.00	25	18	0.72	8	1	5.55	25	146	5.84	8
Aluminum fluoride Al_2F_6 (C. P.)	0.50	50	188	3.76	10	0	0.00	50	235	4.70	10
Do	1.00	25	126	5.04	7	13	10.32	25	195	7.80	7
Arsenic oxide, As_2O_5 (C. P.)	0.50	50	5	0.10	6.5	0	0.00	50	352	7.04	6.5
Arsenious oxide, As_2O_3 (C. P.)	0.50	50	11	0.22	6.5	0	0.00	50	436	8.72	6.5
Barium carbonate, $BaCO_3$ (C. P.)	1.00	25	61	2.44	6	13	21.31	25	110	4.40	6
Barium cyanide, $Ba(CN)_2$ (pure)	1.00	25	3	0.12	6	0	0.00	25	148	5.92	6
Barium fluoride, BaF_2 (C. P.)	0.50	50	41	0.82	5.5	1	2.44	50	63	1.26	5.5
Do	2.00	25	436	17.44	7	86	19.72	25	445	17.80	7
Do	4.00	50	340	6.80	8	72	21.18	50	657	13.14	8
Barium fluosilicate, $BaSiF_6$ (C. P.)	0.50	50	12	0.24	5.5	0	0.00	50	103	2.06	5.5
Do	0.50	50	13	0.26	10.5	0	0.00	50	311	6.22	10.5
Barium thiocyanate, $Ba(CNS)_2 \cdot H_2O$ (C. P.)	1.00	25	4	0.16	6	0	0.00	25	202	8.08	6
Bismuth borate[1] (pure)	0.50	50	51	1.02	11	0	0.00	50	176	3.52	11
Bismuth oxalate $Bi_2(C_2O_4)_3$ (pure)	1.00	25	160	6.40	6	44	27.50	25	97	3.88	6
Do	4.00	25	26	1.04	6	10	38.46	25	21	.84	6
Boric acid, H_3BO_3 (C. P.)	1.00	25	2	0.08	8	0	0.00	25	77	3.08	8
Calcium aluminate $CaAl_2O_4$ (C. P.)	0.50	50	122	2.44	11	0	0.00	50	159	3.18	12
Do	1.00	25	78	3.12	7	10	12.82	25	165	6.60	7
Calcium arsenate $Ca_3(AsO_4)_2$ (C. P.)	0.50	50	1	0.02	11.5	0	0.00	50	308	6.16	12
Calcium arsenite, $CaHAsO_3$ (C. P.)	0.50	50	1	0.02	12	0	0.00	50	144	2.88	12
Calcium borate, $Ca(BO_2)_2 \cdot 2H_2O$ (pure)	0.50	50	18	0.36	9	0	0.00	50	130	2.60	9
Calcium fluoride, CaF_2 (C. P.)	0.50	50	77	1.54	5.5	1	1.30	50	77	1.54	5.5
Do	2.00	25	345	13.80	7	162	47.00	25	458	18.32	7
Calcium fluosilicate[1]	0.50	50	82	1.64	5.5	1	1.22	50	169	3.38	5.5
Do	2.00	50	192	3.84	6	32	16.66	50	262	5.24	7
Chromus fluoride, CrF_2 (C. P.)	0.50	50	36	.72	9	0	0.00	50	388	7.76	9

Cupric ammonium fluoride, $CuF_2 . Cu(OH)_2 . 4NH_3 . 2NH_4F . 2H_2O$ (C. P.)	0.50	50	2	0 04	11	0	0.00	50	147	2.94	11
Cupric aceto-arsenite, $(CuOAs_2O_3)_3 Cu(C_2H_3O_2)_2$ (Paris green)	0.50	50	9	0.18	5.5	6	66.66	50	241	4.82	5.5
Cupric arsenate, $Cu_3(AsO_4)_2 . 4H_2O$ (C. P.)	0.50	50	3	0.06	10.5	0	0.00	50	185	3.70	10.5
Cupric arsenite, $CuHAsO_3$ (C. P.)	0.50	50	2	0.04	10.5	0	0.00	50	156	3.12	10.5
Cupric borate[1] (pure)	0.50	50	1	0.02	11	0	0.00	50	104	2.08	11
Cupric fluoride, $CuF_2 . 2H_2O$ (C. P.)	1.00	25	4	0.16	6.5	0	0.00	25	367	14.68	6.5
Cupric sulphate, $CuSO_4 . 5H_2O$ (C.P.)	1.00	25	14	0.56	7	2	14.30	25	215	8.60	7
Cuprous thiocyanate, CuCNS (C.P.)	0.50	50	149	2.98	9.5	8	5.37	50	138	2.76	9.5
Do.	2.00	50	188	3.76	7	13	6.91	50	168	3.36	7
Do.	4.00	25	2	08	6	2	100.00	25	16	0.64	6
Ferric arsenite, $2FeAsO_3 . Fe_2O_3 . 5H_2O$ (pure)	0.50	50	4	.08	10	0	0.00	50	132	2.64	10
Ferrous arsenate, $FeAsO_4 . 2H_2O$ (pure)	0.50	50	6	0.12	9.5	0	0.00	50	157	3.14	9.5
Lead arsenate, Pb $HAsO_4$	0.50	50	73	1.46	5.5	2	2.74	50	88	1.76	5.5
Do.	0.50	50	13	0.26	7	4	30.77	50	235	4.70	7
Lead borate, $Pb(BO_2)_2 . H_2O$ (pure)	2.00	50	60	1.20	10.5	0	0.00	50	244	4.88	10.5
Lead cyanide, $Pb(CN)_2$ (C. P.)	0.50	50	206	4.12	10.5	lost	—	50	138	2.76	10.5
Do.	1.00	25	42	1.68	7	8	19.5	25	74	2.96	7
Do.	2.00	50	195	3.90	8	37	18.97	50	342	6.84	8
Lead fluoride, PbF_2 (C. P.)	0.50	50	185	3.70	11	1	0.54	50	216	4.32	11
Do.	1.00	25	2	.08	7	0	0.00	25	65	2.60	7
Lead formate, $Pb(CHO_2)_2$ (pure)	1.00	25	48	1.92	7	16	33.33	25	48	1.92	7
Do.	2.00	50	526	10.52	7	176	33.46	50	396	7.92	7
Do.	4.00	25	3	0.12	6	1	33.33	25	31	1.24	6
Lead fluosilicate[1]	1.00	25	3	0.12	10.5	0	0.00	25	40	1.92	10.5
Lead oxalate, PbC_2O_4 (C. P.)	1.00	25	50	2.00	7	11	22.00	25	57	2.28	7
Do.	2.00	50	547	10.94	7	132	24.13	50	592	11.84	7
Do.	4.00	25	23	0.92	6	8	34.78	25	13	.52	6
Lead oxide, PbO (yellow) (C. P.)	1.00	25	158	6.32	7	12	7.60	25	213	8.52	7
Lead thiocyanate, $Pb(CNS)_2$ (pure)	1.00	25	14	0.56	10.5	1	7.14	25	60	2.40	10.5
Lithium chloride, LiCl (pure)	1.00	25	1	0.04	7	0	0.00	25	142	5.68	7
Lithium fluoride, LiF (C. P.)	1.00	25	3	0.12	10.5	0	0.00	25	26	1.04	10.5

[1]This is a commercial compound of unknown chemical composition.

TABLE 1. *Concluded*

Compound	Concentration, per bait. in grams	Poison baits: Total number of baits	Total number of larvae	Average per bait	Days in soil	No. dead when examined 1 week later	Per cent killed	Control baits: Total number of baits	Total number of larvae	Average per bait	Days in soil
Magnesium borate, $Mg(BO_2)_2 8H_2O$ (C. P.)	1.00	25	2	0.08	10.5	0	0.00	25	49	1.96	10.5
Magnesium fluoride, MgF_2 (C. P.)	1.00	25	47	1.88	10.5	3	6.40	25	44	1 76	10.5
Magnesium fluosilicate, $MgSiF_6$ (purified)	1.00	25	0	0.00	10.5	0	0.00	25	60	2.40	10.5
Manganous fluoride, MnF_2 (C. P.)	1.00	25	6	0.24	8	0	0.00	25	149	5.96	8
Mercuric arsenate, $Hg_3(AsO_4)_2$ (pure)	1.00	25	0	0.00	8	0	0.00	25	61	2.44	8
Mercuric chloride. $HgCl_2$ (C. P.)	0.50	50	0	0.00	5.5	0	0.00	50	56	1.12	5.5
Mercuric oxalate, HgC_2O_4 (pure)	1.00	25	1	0.04	7	0	0.00	25	104	4.16	7
Mercuric thiocyanate, $Hg(CNS)_2$ (pure)	1.00	25	0	0.00	7	0	0.00	25	35	1.40	7
Mercurous arsenite[1] (pure)	0.50	50	13	0.26	5.5	1	7 70	50	173	3.46	5.5
Mercurous chloride. Hg_2Cl_2 (C. P.)	0.50	50	144	2.88	5.5	11	7.64	50	168	3.36	5.5
Do.	1.00	50	156	3.12	6.5	4	2.57	50	278	5.56	6.5
Do.	1.00	50	89	1.78	7.5	16	18.00	50	1,124	22.48	7.5
Do.	4.00	50	82	1.64	7	18	22.00	50	622	12.44	7
Nickel chloride, $NiCl_2.6H_2O$ (C. P.)	1.00	25	1	0.04	8	1	100.00	25	36	1.44	8
Nickelous borate. $NiB_2O_4 . 2H_2O$ (C. P.)	1.00	25	1	0.04	8	0	0.00	25	40	1.60	8
Potassium arsenate, KH_2AsO_4 (C. P.)	1.00	25	2	0.08	8	0	0.00	25	67	2.68	8
Potassium arsenite, $KAsO_2$ (C. P.)	1.00	25	0	0.00	8	0	0.00	25	92	3.68	8
Potassium tetraborate, $K_2B_4O_7.5H_2O$ (C. P.)	1.00	25	13	0.52	7	0	0.00	25	223	8.92	7
Potassium chromate, K_2CrO_4 (C. P.)	1.00	25	0	0.00	7	0	0.00	25	242	9.68	7
Potassium dichromate, $K_2Cr_2O_7$ (tech.)	1.00	25	0	0.00	8	0	0.00	25	180	7.20	8
Potassium fluoride, KF (C. P.)	1.00	25	0	0.00	8.5	0	0.00	25	87	3.48	8.5
Potassium fluosilicate. K_2SiF_6 (C.P.)	0.50	50	28	0.56	5.5	0	0.00	50	185	3.70	5.5
Potassium oxalate, $K_2C_2O_4H_2O$ (C.P.)	1.00	25	124	4.96	7	8	6.45	25	154	6.16	7
Potassium phenylate, KOC_6H_5 (pure)	1.00	25	46	1.84	7	3	6.52	25	216	8.64	7

Sodium aluminum fluoride, Na_3AlF_3 (cryolite, powder)	1.00	25	93	3.72	7	14	15.05	25	98	3.92	7
Do.	2.00	50	211	4.22	7	14	6.63	50	178	3.56	7
Sodium arsenate, $Na_2HAsO_4.7H_2O$ (C. P.)	0.50	50	1	0.02	6.5	0	0.00	50	233	4.66	6.5
Sodium arsenite, Na_2HAsO_3 (C. P.)	0.75	100	42	0.42	5	0	0.00	100	396	3.96	5
Sodium tetraborate, $Na_2B_4O_7 . 10H_2O$ (U. S. P.)	1.00	25	9	0.36	8.5	1	11.11	25	91	3.64	8.5
Sodium chlorate, $NaClO_3$ (C. P.)	1.00	25	16	0.64	7	3	18.75	25	89	3.56	7
Sodium citrate, $Na_3C_6H_5O_7 . 2H_2O$ (U. S. P.)	1.00	25	38	1.52	7	1	2.63	25	153	6.12	7
Sodium fluoride, NaF (pure)	0.50	50	2	0.04	5.5	0	0.00	50	191	2.82	5.5
Sodium fluosilicate, Na_2SiF_6	0.50	50	17	0.34	5.5	1	5.88	50	225	4.50	5.5
Sodium thiocyanate, NaCNS (C. P.)	1.00	25	29	1.16	6.5	7	24.14	25	425	17.00	6.5
Zinc arsenate, $Zn_3(AsO_4)_2 . 8H_2O$ (pure)	1.00	25	1	0.04	6.5	0	0.00	25	494	19.76	6.5
Zinc arsenite, $Zn_3(AsO_3)_2$ (pure)	1.00	25	1	0.04	6.5	0	0.00	25	402	16.08	6.5
Zinc cyanide, $Zn(CN)_2$	1.00	25	86	3.44	6.5	9	10.46	25	278	11.12	6.5
Do.	2.00	50	95	1.90	6	2	2.10	50	283	5.66	6
Totals or averages		3,600	6,381	1.77		1 003	15 71	3,600	19,069	5.29	

[1]This is a commercial compound of unknown chemical composition.

TABLE 2. DATA SHOWING TOXICITY OF VARIOUS ORGANIC COMPOUNDS WHEN USED IN BAITS FOR THE CONTROL OF WIREWORMS

		Poison baits						Control baits			
Compound	Concentration, per bait, in grams	Total number of baits	Total number of larvae	Average per bait	Days in soil	No. dead when examined 1 week later	Per cent killed	Total number of baits	Total number of larvae	Average per bait	Days in soil
Acetamide	1.00	25	324	12.96	7.5	32	9.88	25	301	12.04	7.5
Do	2.00	50	83	1.66	8	16	19.28	50	620	12 40	8
Acetamide Sodium arsenite, Na_2HAsO_3 (C. P.)	1.00 1.00	25	2	.08	8	0	0.00	25	645	25.80	8
Acetanilid	1.00	25	29	1.16	7.5	2	6.89	25	216	8.64	7.5
Acetophenetidine	1.00	25	160	6.40	7.5	17	10.62	25	336	13.44	7.5
Acetophenylenediamine	.50	25	1	.04	5	1	100.00	25	30	1.20	5
Acetylene tetrachloride	1.58	25	0	.00	7	0	0.00	25	225	9.00	7
o-Aminobenzoic acid	1.00	25	248	9.92	6	91	36.69	25	406	16.24	6
Do	2.00	50	413	8.26	8	111	26.87	50	885	17.70	8
Do	3.00	25	69	2.76	7	2	2.90	25	312	12.48	7
Do Sodium arsenite, Na_2HAsO_3 (C. P.)	1.00 1.00	25	0	.00	8	0	0.00	25	346	13.84	8
Aniline	1.00	25	0	.00	6	0	0.00	25	38	1.52	6
Atropine	.20	25	4	.16	5	0	0.00	25	54	2.16	5
Carbazole	1.00	25	103	4.12	6.5	10	9.70	25	274	10.96	6.5
Do	2.00	25	48	1.92	7	5	10.42	25	300	12.00	7
Cinchonidine	1.00	25	10	.40	6	6	60.00	25	20	.80	6
Cinchonine	1.00	25	13	.52	6	9	69.23	25	29	1.16	6
Citric acid	1.00	25	43	1.72	8	4	9.30	25	76	3.04	8
Dibenzylamine	1.03	25	19	.76	7	0	0.00	25	571	22.84	7
N - dimethyl - p -phenylenediamine hydrochloride	.50	25	2	.08	5	2	100.00	25	27	1.08	5
1:2:4-Dinitrophenol	1.00	25	0	.00	6	0	0.00	25	701	28.04	6
Diphenylamine	1.00	25	63	2.52	7	5	7.93	25	238	9.52	7
Hellebore root (white)	1.00	25	159	6.36	7	19	11.95	25	257	10.28	7
Do	4.00	50	363	11.26	7	168	29.84	50	711	14.22	7
Hexamethylenetetramine	1.00	25	71	2.84	7	14	19.72	25	157	6.28	7
Iron quinine and strychnine citrate	1.00	25	112	4.48	7	25	22.32	25	103	4.12	7
Do	2.00	25	6	.24	6	3	50.00	25	11	.44	6
Malachite green	1.00	25	12	.48	7	4	33.33	25	328	13.12	7
Methyl cyanide	.50	50	126	2.52	6.5	1	0.80	50	181	3.62	6.5
Do	1.00	50	716	14.32	8	297	41.48	50	588	11.76	8

Naphthylamine, alpha- (tech.)	1.00	25	1	.04	6	1	100.00	25	977	39.08	6
Do. (C. P.)	1.00	25	5	.20	6	4	80.00	25	523	20.92	6
Nicotine	.125	25	331	13.24	7	74	22.36	25	254	10.16	7
Do.	.25	25	2	.08	7	0	0.00	25	343	13.72	7
o-Nitraniline	1.00	25	0	.00	6	0	0.00	25	48	1.92	6
m-Nitraniline	1.00	25	22	.88	6	9	40.90	25	35	1.40	6.
p-Nitraniline	1.00	25	1	.04	6	0	0.00	25	51	2.04	6
m-Nitrobenzaldehyde	1.00	25	358	14.32	7	142	39.66	25	389	15.56	7
Do.	2.00	50	110	2.20	7	23	20.90	50	989	19.78	8
Do. / Sodium arsenate, $Na_2HAsO_4.7H_2O$ (C. P.)	1.00 / 1.00	25	2	.08	8	0	0.00	25	559	22.36	8
m-Nitrobenzaldehyde / Sodium arsenite, Na_2HAsO_3 (C. P.)	1.00 / 1 00	25	1	.04	8	0	0.00	25	493	19.72	8
Mononitronaphthalene, alpha-(tech.)	1.00	25	37	1.48	6	11	29.73	25	459	18.36	6
p-Nitrophenol (tech.)	1.00	25	2	.08	6	0	0.00	25	836	33.44	6
o-Nitrotoluene	1.17	25	0	.00	7	0	0.00	25	191	7.64	7
Oxalic acid	1.00	25	53	2.12	6	25	47.17	25	56	2.24	6
p-Phenylenediamine	.05	25	196	7.84	7	32	16 33	25	225	9.00	7
Do.	.10	25	279	11.16	7	33	11.83	25	424	16.96	7
Do.	.30	25	207	8.28	7	184	88.88	25	506	20.24	7
Do.	.50	25	101	4.04	7	89	88.12	25	309	12.36	7.
Do.	.70	25	138	5.52	8	119	86.23	25	397	15.88	8
Do.	.90	25	170	6.80	8	139	81.77	25	365	14.60	8
Do.	1.00	25	133	5.32	6	94	70.68	25	650	26.00	6
m-Phenylenediamine	1.00	25	38	1.52	8	0	0.00	25	106	4.24	8
Piperidine	.25	25	131	5.24	6	22	16.80	25	180	7.20	7
Do.	.50	25	138	5.52	8	31	22.46	25	259	10.36	8
Piperine	1.00	25	310	12.40	7.5	46	14.86	25	323	12.92	7.5
Do	1.50	50	744	14.88	7	193	25.94	50	769	15.38	7
Quinoline	.25	25	4	.16	7	4	100.00	25	325	13.00	7
Strychnine arsenite	.50	50	13	.26	6.5	1	7.69	25	323	12.92	6.5
Tetramethylammonium hydroxide	.25	25	423	16.92	7	99	23.40	25	363	14.52	7
Triphenylphosphate (tech.)	1.00	25	445	17.80	7	109	24.50	25	601	24.04	7
Do.	2.00	50	418	8.36	8	58	13.89	50	672	13.44	8
Do. / Sodium arsenate, $Na_2HAsO_4.7H_2O$ (C. P.)	1.00 / 1.00	25	0	.00	8	0	0.00	25	260	10.40	8
Triphenylphosphate (tech.) / Sodium arsenite, Na_2HAsO_3 (C. P.)	1.00 / 1.00	25	0	.00	8	0	0.00	25	396	15.84	8
Veratrine (U. S. P.)	.25	25	212	8.48	7	70	33.02	25	487	19.48	7
Do.	.50	25	135	5.40	7	27	20.00	25	550	22.00	7
Totals or averages		1,875	8,359	4.46		2.483	29.70	1,875	23,679	12.63	

lent Paraphenylenediamine is the only compound that showed any promise as an effective poison in these baits.

For many years poison-bait experiments have been conducted against wireworms, *Limonius* (*Pheletes*) *canus* Lec., but with little success. Along with other wireworm investigations in the Pacific Northwest, it was felt that a fairly large number of poisons should be tried out systematically with controls, so that positive or negative results could be definitely shown

PREPARATION OF BAITS. The baits consisted of ground whole wheat, the compound under test,[3] and sufficient water to hold the mixture together The insoluble compounds were weighed and mixed thoroughly with the dry ground whole wheat before the water was added A special effort was made to see that the poison was evenly distributed through the baits. When a colored compound was used, it was shown that an even distribution was obtained by this method The soluble compounds were dissolved in water and then added to the ground whole wheat. The mixture was then kneaded into the shape of a ball The balls weighed about 60 grams, or 2 ounces, when ready for the field The same number of control baits, consisting of whole wheat and water but no poison, were made in all cases.

After the baits were made they were covered with a moist cloth to conserve the moisture until placed in the soil It was noticed that moisture was an important factor in these experiments, since larvae were seldom found in baits that had dried.

PROCEDURE. The field was marked off with a wooden marker, in the earlier experiments into 1-foot squares, but later into 2-foot squares This change had no effect on the comparison of the results, however. At the intersections of these squares the baits were placed in the soil, one at a time, with a hand potato planter, a poison bait being alternated with a control. Each bait was marked with a 10-inch pot label and the ground stamped down. In the earlier experiments the baits were placed about 2 to 3 inches deep. Sifting records showed that, at the locality baited, the majority of the larvae were around 3 inches deep. Later, when the records showed that the larvae were at a greater depth, the baits were placed deeper, until during July and August they were placed at a depth of about 8 inches. Previously baiting had been discontinued at this station during these months, since the larvae were not feeding near the surface at this time, probably because of the high

[3]Chemically pure compounds were used in this investigation whenever they were obtainable.

temperature. It was found during this investigation, however, that the larvae would come to the baits if the baits were placed deep enough.

The baits were left in the soil for varying lengths of time. Each bait was taken up singly with a hand trowel, together with the adhering soil. From three to six baits, depending upon the number of larvae present, were placed on the screen of the power sifter, where they were broken on an 8-mesh screen and sifted through 16 and 30 mesh screens. The larvae were counted, and those taken from the poison baits were retained in soil for a week before the final examination was made.

The same procedure was used with baits containing each of the compounds listed in Tables 1 and 2.

RESULTS. Tables 1 and 2 summarize the results obtained. The data in Table 3 have been taken from Table 1, and show very clearly the repellent effect of arsenical compounds.

TABLE 3 REPELLENCY OF ARSENICAL COMPOUNDS TO *Limonius canus* LARVAE

Compound	Number of poison baits	Number of larvae in poison baits	Number of control baits	Number of larvae in control baits
Calcium arsenate	50	1	50	308
Calcium arsenite	50	1	50	144
Paris green	50	9	50	241
Cupric arsenate	50	3	50	185
Cupric arsenite	50	2	50	156
Ferric arsenite	50	4	50	132
Ferrous arsenate	50	6	50	157
Lead arsenate	100	86	100	323
Mercuric arsenate	25	0	25	67
Mercurous arsenite	50	13	50	173
Potassium arsenate	25	2	25	67
Potassium arsenite	25	0	25	92
Sodium arsenate	50	1	50	233
Sodium arsenite	100	42	100	396
Zinc arsenate.	25	1	25	494
Zinc arsenite	25	1	25	402
Total	675	172	675	3,564
Average number of larvae per bait.		0.25		5.28

DISCUSSION AND CONCLUSION. From the results of these experiments it does not seem that the use of poison baits would be a very efficient method of wireworm control on a large scale, since not all the wireworms can be removed in this manner. In a plot where the soil was first sifted to determine the wireworm population and then baits were placed in the soil a foot apart, a second sifting showed that the wireworm population had been reduced about 50 per cent. To obtain 50 per cent of the larvae, the baiting must be done at the most favorable time, namely, when the soil is warm and the larvae are near the surface.

Poison baits could be used to advantage on small garden plots where the labor involved is not such an important consideration.

The only poison which showed any promise of attracting the larvae in fairly large numbers, and also of killing them, was paraphenylenediamine. This compound is quoted commercially at $1.15 per pound. Although only a small quantity is needed per bait, it would prove quite expensive on a large scale, unless it could be procured cheaper in large quantities.

All the arsenites and arsenates employed in this experiment were very repellent.

EXTRACTIVE EFFICIENCY OF KEROSENE ON PYRETHRUM POWDERS OF VARYING FINENESS[1]

By HENRY H. RICHARDSON, *Crop Protection Institute Investigator, Iowa State College, Ames, Iowa*[2]

ABSTRACT

The extractive efficiency of kerosene on pyrethrum powders of varying degrees of fineness was tested by comparing the insecticidal efficiency of such extracts with standard extracts of pyrethrum containing 50, 75, and 100 per cent of the active constituents. House flies were used in the insecticidal tests and the time, in seconds, until 50 per cent of the flies were paralyzed was used as the main criterion for determining insecticidal power. Mortality data were taken but as reported in a previous paper, the percentage kill was not a sufficiently sensitive index to indicate small differences in the pyrethrin content of kerosene extracts. The efficiency of extraction on 12, to 15, 20, 30, and 45 mesh pyrethrum powders was about the same in each case: it is estimated that 80 per cent extraction of the active constituents was obtained. Extraction of 200-mesh pyrethrum powder was more efficient, however, giving approximately 90 per cent of the active constituents. Apparently the achenes, or seeds, which contain a very large percentage of the active constituents, are not thoroughly crushed in powders varying from 12 to 45 mesh, whereas with 200-mesh powder the achenes are entirely broken up. This difference might account for the observed differences in the extractive efficiency of kerosene on these various grades of powder.

Pyrethrum powder, which consists of the ground heads of the chrysanthemum daisy (*Chrysanthemum cinerariaefolium* Vis. and other closely related species of the same genus) has extensive use in this country in the preparation of household sprays. Such sprays consist mainly of kerosene extracts of pyrethrum.

Two esters, pyrethrin 1 and pyrethrin 2, have been found to be the

[1]Part of a thesis presented to the graduate faculty of Iowa State College in partial fulfillment of the requirements for the degree of doctor of philosophy.

[2]The author is now with the United States Department of Agriculture, Bureau of Entomology, Washington, D. C.

active constitutents of pyrethrum (6, 7). These two compounds are soluble in most organic solvents, such as alcohol, acetone, petroleum ether and other hydro-carbon solvents such as kerosene. Two methods are in use for the preparation of kerosene extracts of pyrethrum. First the extraction of the powder by several treatments or by continuous extraction with a volatile solvent such as petroleum ether, naphtha or ethylene dichloride (3b) followed by evaporation to remove the volatile solvent and taking up the oily residue in kerosene. By this method, 95 to 100 per cent extraction of the active constituents of pyrethrum can be accomplished. Maceration and percolation of the pyrethrum powder with kerosene is the simpler method, but it has the disadvantage that the completeness of extraction is uncertain.

Pyrethrum is marketed in several degrees of fineness, the coarse form (passing through a sieve 12 to 15 mesh), the 30 to 40 mesh powder, and the 200 mesh powder. There is considerable difference of opinion among dealers as to how finely a pyrethrum powder should be ground in order to give maximum efficiency with kerosene extraction. The experiments described in this paper were undertaken to determine the extractive efficiency of kerosene on pyrethrum powders of varying degrees of fineness.

One might suppose that this problem could be approached from the chemical angle--that is by the chemical analysis before and after extraction with kerosene. Tattersfield and Hobson's short acid method (8) was tried, but the kerosene present in the extracted powder apparently interfered with the analysis. Since the completion of this research, Vollmar (9) has reported a slight adaptation of this acid method by which he was able to quantitatively determine the amount of pyrethrin 1 in a known extract. However, inasmuch as the final criterion of the amount of active insecticidal constituents would be obtained by the biological rather than by the chemical method, this problem was approached from that angle—by the use of comparative insecticidal tests.

Materials and Methods. *Pyrethrum*—Coarsely ground (15 to 20 mesh) powder was obtained freshly from the importer. Analysis by the short acid method showed a content of 0.26 per cent pyrethrin 1. The powder was prepared to various degrees of fineness (20, 30, and 45 mesh) by grinding the entire sample of the previously well mixed powder through a Wiley mill. Because of the difficulty of grinding samples of powder to a very fine mesh with a laboratory mill, a 200-mesh powder was obtained directly from the importer.

Kerosene—of mid continent origin—gravity 41.2° A.P.I. (sp. gr. 0.8197) distillation range of 376° to 516° F. (192–269°C.)

Method of preparing extracts—The correct amount of pyrethrum powder was placed in a cylindrical glass percolator, the bottom hole of which was plugged with cotton and a foil-covered cork stopper. Enough kerosene to thoroughly wet the powder was added, and this was allowed to macerate (or thoroughly soak) the powder for several hours. The cork stopper was then removed and percolation allowed to proceed at the rate of 10 to 20 drops per minute. With the 200-mesh powder no regulation was necessary, as the powder packed closely and percolation proceeded slowly. With the coarse grades of powders the rate of percolation was regulated by means of a dropping funnel. Filter paper discs were placed on the powder so that an even distribution of the kerosene was obtained at the top of the column of powder

PROCEDURE Extracts (1 pound to 1 gallon, or 11 9 grams per 100 cc of kerosene) of powders varying in degree of fineness from 12 to 15 mesh, 20 mesh, 30 mesh, and 45 mesh were prepared by the method just described. From the same lot of pyrethrum powder standard extracts of known concentration were prepared in the following manner. A known weight of powder was extracted with petroleum ether for 5 hours in a Soxhlet extractor This gave complete extraction of active constituents. The petroleum ether extract was then evaporated in a current of carbon dioxide. The oily residue, which contained all the pyrethrins in the known weight of powder was then dissolved in a known volume of kerosene. Standard solutions of ½, ¾, and 1 pound per gallon strengths (5.9, 8.9, 11.9 gms respectively, per 100 cc.) were made in this way

The standard extract 1 pound to 1 gallon represented 100 per cent extraction, the standard extract ¾ pound to 1 gallon represented 75 per cent extraction, the standard extract ½ pound to 1 gallon represented 50 per cent extraction. By comparing the insecticidal power of these standard solutions with the pyrethrum extractions prepared by percolation, as described above, an index of the relative efficiency of kerosene extractions of the various grades of powder could be obtained.

The various extracts were tested by an insecticidal method which has been previously described (6). From forty to sixty house flies of uniform age were sprayed with the extracts and data on the speed of paralytic action and final mortality were taken Peet and Grady have described a method for testing kerosene extracts of pyrethrum on flies (5) in which the percentage kill produced by the spray is used as the main criterion for determining the strengths of kerosene extracts of pyrethrum. The pyrethrins are of course very toxic insect poisons,

but even more striking than the final kill that they produce is the speed with which they paralyze insects. This paralyzing effect is perhaps the outstanding characteristic of the pyrethrins Very few contact insecticides even approach them in this respect. Certainly it is a toxic effect which not only can be determined with more accuracy, but which is far more sensitive to changes with pyrethrin concentration than the final kill produced by kerosene extracts of pyrethrum. As has been shown in a previous paper the 50 per cent paralytic point (the time in seconds when 50 per cent of the flies are paralyzed) furnishes an accurate index of the quantity of pyrethrins present and it has been used here for estimating differences in the kerosene extracts of various mesh pyrethrum powders.

All the extracts in any one series of tests were tested on the same day, since the resistance of flies varies from day to day, and from season to season. Only by performing an entire series on the same day, under the same conditions and with flies of the same age, could the results be made comparable.

A preliminary series was first made in which extracts of 12 to 15 mesh, 20 mesh, and 45 mesh were compared with the standard extracts. A summary of the data obtained in this series is given in Table 1.

TABLE 1. INSECTICIDAL EFFICIENCY OF KEROSENE EXTRACTS OF PYRETHRUM POWDER OF VARYING FINENESS (MARCH 1930, PRELIMINARY SERIES)

Solution	Tests No.	Flies No.	Ave. 50 per cent paralytic point in seconds
(1) Kerosene	3	142	238
(2) Standard Extract 1 lb. to 1 gal	3	165	140
(3) Standard Extract ¼ lb. to 1 gal	3	162	159
(4) Extract of 12 to 15 mesh powder	3	169	151
(5) Extract of 20 mesh powder	3	157	158
(6) Extract of 45 mesh powder	3	166	151

Average kill after 24 hours: No. 1, 44%; No. 2, 51%; No. 3, 55%; No. 4, 65%; No. 5, 55%; No. 6, 63%.

In studying the results of all these experiments it must be borne in mind that the average 50 per cent paralytic point rather than the average percentage kill is the most useful criterion for determining the strength of kerosene extracts of pyrethrum. The mortality data produced by the different extracts did not differ significantly, but they are included for reference at the base of the tables.

From a study of the above table, it appears that there is no significant difference in the insecticidal power of the extracts of the three grades of powder, for they are all approximately equivalent in speed of paralytic action (151–158 seconds). The standard 1 pound to 1 gallon extract,

which represents 100 per cent extraction, paralyzed 50 per cent of the flies in 140 seconds The standard ¾ pound to 1 gallon extract, representing 75 per cent extraction, paralyzed 50 per cent of the flies in 159 seconds. The values for the extracts from the different mesh powders lie between those of these two standard extracts, indicating that kerosene extraction of these powders was between 75 and 100 per cent As

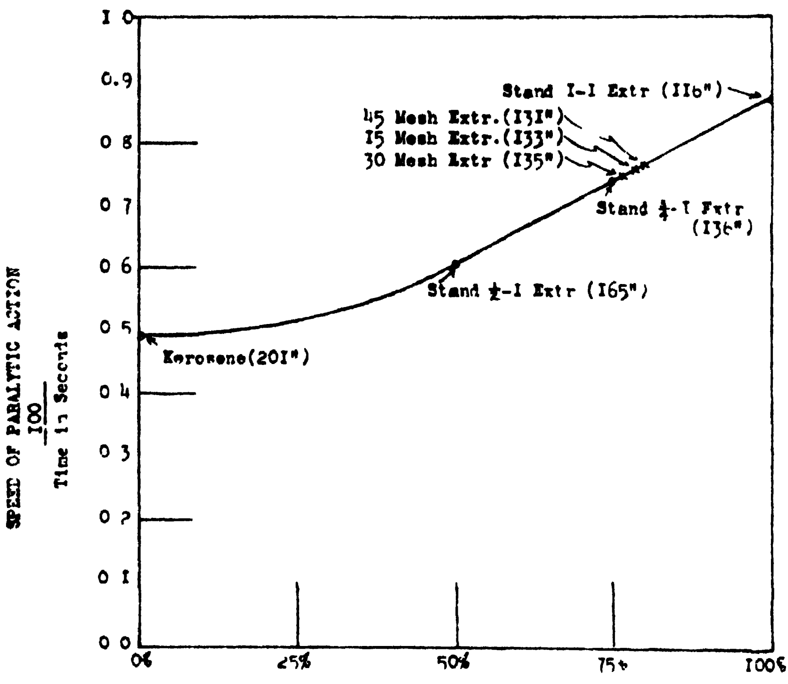

FIG 17 —Extractive efficiency of Kerosene on pyrethrum powders of varying fineness—as indicated by speed of paralytic action

the speed of paralytic action increases in a straight line in the range of these concentrations (see Figure 17 from series 2), the results from this first series indicate that about 80 per cent extraction of the active constituents was obtained The small differences in mortality are not statistically significant Significance was tested by Fisher's method (1) for the determination of the significance of the difference of means.

The fact that there appeared to be no real difference in the extracts prepared from these three grades of powder was the more surprising as previous correspondence with various dealers had claimed definitely that there would be large differences

In order to check these results, a new set of extracts was prepared and tested in a long series on seven different days. The data from this series are given in Table 2

TABLE 2. INSECTICIDAL EFFICIENCY OF KEROSENE EXTRACTS OF VARIOUS GRADES OF PYRETHRUM POWDER. (MARCH 1930, FINAL SERIES)

Solution	Tests *No.*	Flies *No.*	Ave. 50 per cent paralytic point in seconds
(1) Kerosene	7	385	201
(2) Standard extract 1 lb. to 1 gal	7	391	116
(3) Standard extract ¾ lb. to 1 gal	7	387	136
(4) Standard extract ½ lb. to 1 gal	7	453	165
(5) 12 to 15 mesh extract 1 lb. to 1 gal	7	395	133
(6) 30 mesh extract 1 lb. to 1 gal	7	412	135
(7) 45 mesh extract 1 lb to 1 gal	7	386	131

Average kill after 24 hours: No. 1, 67%; No 2, 64%; No. 3 51%; No. 4, 57%; No. 5, 69%; No 6, 62%, No. 7, 67%.

From these data it can be seen that the results obtained in the preliminary series are corroborated For the second time extracts of pyrethrum powders varying from 12 to 15 up to 45 mesh appeared to be approximately equivalent in insecticidal power (the respective 50 per cent paralytic points in seconds varied from 131 to 133 and 135). The standard 1 pound to 1 gallon extract representing 100 per cent extraction, gave a 116 second paralytic point whereas the standard ¾ pound to 1 gallon extract (75 per cent extraction) gave a 136-second paralytic point. Comparisons of all these values indicated that the various grades of powders gave an extractive efficiency of about 80 per cent. This conclusion is perhaps better illustrated in the graph.

Statistical analysis, by Fisher's method, of the mortalities produced by the various extracts indicated that there were no significant differences here, except between the standard ¾ pound to 1 gallon extract and the extract of the 12 to 15 mesh powder This difference is apparently greater than might be expected from the errors of random sampling. However, the most important thing is that there is no apparent difference in the insecticidal power, as indicated either by the speed of paralytic action or by the average mortality of the extracts made from equivalent amounts of the 12 to 15 mesh, 30 mesh, or 45 mesh pyrethrum powders.

In order to test the extractive efficiency of a 200-mesh powder, a commercially ground powder was used. Standard extracts of ¾ pound and 1 pound per gallon strengths were prepared from this powder according to the method previously described. A 1 pound to 1 gallon extract was prepared by the usual kerosene percolation method These

solutions were then tested comparatively in a series performed on eight different days. The data are given in Table 3.

TABLE 3. COMPARISON OF INSECTICIDAL EFFICIENCY OF AN EXTRACT OF 200-MESH PYRETHRUM POWDER WITH STANDARD EXTRACTS OF THE SAME POWDER, APRIL, 1930

Solution	Tests No.	Flies No.	Ave 50 per cent paralytic point in seconds
(1) Kerosene	8	385	268
(2) Standard extract 1 lb. to 1 gal	8	407	167
(3) Standard extract ¾ lb. to 1 gal	8	407	206
(4) 200-mesh extract 1 lb. to 1 gal	8	405	180

Average kill after 24 hours: No. 1, 52%, No. 2, 46%, No. 3, 52%, No. 4, 55%.

The standard 1 pound to 1 gallon extract (corresponding to 100 per cent extraction) paralyzed 50 per cent of the flies in 167 seconds, the standard ¾ pound to 1 gallon extract (corresponding to 75 per cent extraction) gave a 50 per cent paralytic time of 206 seconds. As can be seen, the 50 per cent paralytic time of the extract from the 200-mesh powder (180 seconds) lay between these two. By plotting this point on graph paper as was done in the second series, it appears that the 200-mesh powder gave approximately 90 per cent extraction The mortalities do not vary significantly

It therefore appears evident that all coarse powders varying from 15 to 45 mesh give about the same extractive efficiency, that is, near 80 per cent. However, a fine 200 mesh powder gives a significantly higher extractive efficiency, that is, about 90 per cent

The finding that the extractive efficiency of kerosene varies with the degree of fineness of the powder might be explained by the following observations. The work of previous investigators (Gerad, 2, 1898, Yamamoto, 11, 1919, Gnadinger and Corl, 3a, 1930, McDonnell and coworkers, 4, 1930) has shown that the active principles of pyrethrum are concentrated largely in the achenes (ovaries or seeds) of the flower head. These achenes are in themselves very small, and a microscopical examination shows that when flowers are ground to 15, 20, 30, or 45 mesh, many of the achenes are not broken up On the other hand, with 200 mesh powder the achenes are entirely crushed into very fine particles. This crushing of the achenes naturally leads to a greater extractive efficiency by kerosene, of the active principles which they contain

ACKNOWLEDGMENT. The author wishes to acknowledge with thanks the advice of Dr. C. H. Richardson during the progress of this research. This study was made possible as a Crop Protection Institute Fellowship supported by the Deep Rock Oil Corporation.

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A COMPARISON OF THE EFFECTIVENESS OF SUSTAINED VACUUM AND DISSIPATED VACUUM IN FUMIGATION WITH HYDROCYANIC ACID GAS

By S. E. Crumb and F. S. Chamberlin, *U. S Bureau of Entomology*

Abstract

Experiments in the fumigation of cigars with hydrocyanic acid gas for the destruction of the tobacco beetle (*Lasioderma serricorne* Fab.) show that, under the conditions of these experiments, fumigation with sustained vacuum was more effective than fumigation with dissipated vacuum.

As part of a fumigation program to determine the effectiveness of various fumigants and methods of fumigation against the tobacco beetle (*Lasioderma serricorne* Fab.) in cigars, the writers have carried out two series of experiments which furnish a basis for a comparison of the relative effectiveness of sustained vacuum and dissipated vacuum in fumigation. The fumigant used was commercial liquefied hydrocyanic acid gas, said to contain 96 to 98 per cent of hydrocyanic acid.

In the sustained-vacuum experiments the fumigant was drawn into the evacuated chamber through a vaporizing nozzle, and no air was admitted except the small amount drawn in with the liquid. The period of exposure was reckoned from the time the gas was admitted. In the dissipated-vacuum experiments the fumigant was admitted as described above, a period of from 15 to 20 minutes was allowed for volatilization of the gas, and at the expiration of this period the large air valve was

TABLE 1. RESULTS OF FUMIGATION EXPERIMENTS AGAINST THE TOBACCO BEETLE WITH LIQUID HYDROCYANIC ACID IN VACUUM (VACUUM SUSTAINED)

Dosage per 1,000 cu. ft.	Exposure	Stages used	Mortality	Vacuum Init.	Vacuum Fin.	Temp. Max.	Temp. Min.	Humidity Max.	Humidity Min.
	Hours		%	*In*	*In.*	*°F.*	*°F.*	%	%
14 ozs.	4	200 larvae	100.0	28	27	90	80	—	—
Do.	4	100 larvae	100.0	28	27	90	82	—	—
		40 pupae	100.0						
Do.	4	120 larvae	100.0	28	27	86	80	—	—
		20 pupae	100.0						
1 lb.	4	60 larvae	93.3	26	25	87	77	74	44
Do.	4	50 larvae	100.0	26	25	82	78	76	67
		10 pupae[1]	60.0						
Do.	4	110 larvae	100.0	27	26	90	82	57	40
18 ozs.	4	50 larvae	100 0	26	24	86	77	88	54
		10 pupae[1]	80.0						
20 ozs.	4	60 larvae	100.0	26	24	83	78	84	60
Do.	4	52 larvae	100.0	26	24	84	80	81	65
		8 pupae[1]	38.0						
1½ lbs	4	30 larvae	100.0	26	24	92	83	68	43
		30 pupae[1]	87.0						
2 lbs.	4	45 larvae	100.0	26	24	89	82	73	50
		15 pupae[1]	93.3						
2½ lbs.	4	60 larvae	100.0	26	24	86	79	92	56
Do.	4	27 larvae	100.0	26	24	78	76	90	82
		33 pupae[1]	94.0						
3 lbs.	4	60 larvae	100.0	26	24	87	81	58	42
		5 pupae[1]	100.0						
Do.	4	40 larvae	100.0	26	24	83	81	70	51
		40 pupae[1]	100.0						
Do.	4	55 larvae	100.0	26	25	91	80	77	45
		25 pupae[1]	100.0						
		20 adults	100.0						
Do.	4	80 larvae	100.0	27	25	81	76	46	38
		30 pupae[1]	100.0						
3½ lbs.	4	34 larvae	100.0	26	24	82	72	88	62
		32 pupae[1]	100.0						

[1]Pupae in normal cells in capsuled tobacco.

opened and the air was allowed to rush in until the vacuum was completely dissipated. The period of exposure was reckoned from the time the large air valve was opened, thus allowing a slightly longer actual exposure than was given in the sustained-vacuum experiments.

In these experiments the larval and pupal stages of the cigarette beetle were placed in gelatin capsules partially filled by a firm wad of tobacco, in which the larvae were allowed to become established before

fumigation, and several small holes were punched in the cap of each capsule. These capsules were then rolled into cigars by professional cigar-makers, two capsules to each cigar, somewhat removed from either end. The same size and type of cigars was used in all experiments, and these were placed in the bottom row of a loosely-filled cigar box, the lid of which was held slightly open by inserting a match stick beneath the edge. The box was placed for fumigation on a grating near the bottom

TABLE 2. RESULTS OF FUMIGATION EXPERIMENTS AGAINST THE TOBACCO BEETLE WITH LIQUID HYDROCYANIC ACID IN VACUUM (VACUUM DISSIPATED)

Dosage per 1,000 cu. ft.	Exposure	Stages used	Mortality	Vacuum Init.	Vacuum Fin.	Temp. Max.	Temp. Min.	Humidity Max.	Humidity Min.
	Hours		%	*In.*	*In.*	°*F.*	°*F.*	%	%
15 ozs.	4	50 larvae	80.0	27	0	84	76	82	79
Do.	4	50 larvae	96.0	27	0	79	71	50	34
1 lb.	4	60 larvae	93.4	26	0	88	81	70	50
Do.	4	60 larvae	71.7	26	0	85	80	70	52
Do.	4	75 larvae	68.0	26	0	86	75	74	46
18 ozs.	4	60 larvae	95.0	26	0	88	87	52	48
20 ozs.	4	60 larvea	83.4	26	0	86	80	75	50
Do.	4	60 larvae	76.7	26	0	84	78	75	56
1½ lbs.	4	60 larvae	98.3	26	0	90	85	51	42
2 lbs.	4	51 larvae	98.1	26	0	90	81	65	48
		9 pupae[1]	77.8						
2½ lbs.	4	57 larvae	100.0	26	0	88	80	80	60
		3 pupae	66.7						
Do.	4	59 larvae	100.0	26	0	82	76	90	70
		1 pupa	100.0						
3 lbs.	4	32 larvae	100.0	26	0	84	78	72	56
		36 pupae[1]	75.0						
		12 adults	100.0						
Do.	4	26 larvae	100.0	26	0	93	87	60	45
		9 pupae[1]	100 0						
		14 adults	100.0						
Do.	4	55 larvae	100.0	26	0	89	77	81	49
		14 pupae[1]	85.7						
Do.	4	50 larvae	100.0	26	0	85	82	54	40
		20 pupae	65.0						
3½ lbs.	4	25 larvae	100.0	26	0	87	77	80	54
		20 pupae[1]	95.0						

[1]Pupae in normal cells in capsuled tobacco.

of the fumigation chamber, and at the end of the treatment the capsules were removed from the cigars at once and kept in pasteboard boxes under conditions favorable to the survival of the treated insects. All fumigations were carried out in an air-tight cannery kettle of 35 cubic feet capacity.

Examination was made six days after treatment and again later if there was any uncertainty in regard to mortality. Check larvae and pupae kept at various times in the course of the experiments showed a mortality of about 13 per cent. Check eggs hatched fairly well in nearly all cases.

The results of these experiments are indicated in Tables 1 and 2.

As indicated in Table 1, 14 to 20 ounces of liquefied hydrocyanic acid gas with an exposure of 4 hours in sustained vacuum gave an average mortality for larvae of over 99.8 per cent. Only one larva survived out of the 802 treated in the nine experiments. At dosages of from 1.5 to 3.5 pounds with an exposure of 4 hours in sustained vacuum 100 per cent of the 431 larvae and 96.7 per cent of the pupae were killed. Seven pupae survived out of the 210 treated in the nine experiments.

As indicated in Table 2, 15 to 20 ounces of liquefied hydrocyanic acid gas with an exposure of 4 hours in dissipated vacuum gave an average mortality for larvae of 82.3 per cent. Eighty-four larvae survived out of the 475 treated in 8 experiments. At dosages of from 1.5 to 3.5 pounds with an exposure of 4 hours in dissipated vacuum 99.52 per cent of the larvae and 80.4 per cent of the pupae were killed Two larvae out of 415 and 22 pupae out of 112 survived in the 9 experiments.

With a slight advantage in the length of the fumigation period dissipated vacuum fumigations showed 17.5 per cent less mortality for larvae at dosages of 15 to 20 ounces of the fumigant than was obtained in the sustained-vacuum experiments. At dosages of from 1.5 to 3.5 pounds, the dissipated-vacuum fumigations show 0.48 per cent less mortality for larvae and 16.3 per cent less mortality for pupae than was obtained in the sustained-vacuum experiments. It is evident that, under the conditions of the writers' experiments, sustained-vacuum fumigation was more effective than that in which the vacuum was dissipated

A CONSIDERATION OF "INTERVAL SHOOTING" AS PRACTICED IN CITRUS FUMIGATION

By H. L. CUPPLES, *Bureau of Chemistry and Soils, Department of Agriculture, Whittier, California*

ABSTRACT

It has been shown that, for the purpose of obtaining a maximum value of $\int C\,dt$ from a given quantity of fumigant, interval shooting apparently is less advantageous than the usual procedure of introducing the entire charge of fumigant at the beginning of the fumigation period.

The general practice in citrus fumigation is to introduce the entire dose of fumigant at the beginning of the fumigation period, allowing its concentration throughout the remainder of the period to be governed by the prevailing conditions. It is well known that in tent fumigation of citrus trees with hydrocyanic acid the initial concentration of hydrocyanic acid is rapidly dissipated. This loss of active material occurs in a number of different ways, including diffusion through the canvas, ab-

sorption by vegetation within the tent and leakage through tears in the tent fabric or around the base of the tent. Because of the variability of these factors the rate of loss may vary considerably from tent to tent.

Various schemes have been devised which aim to increase the effectiveness of tent fumigation. One of these is to use a relatively gas-tight fabric for the material of the tent, which of course greatly reduces the rate of loss of hydrocyanic acid. This scheme has not yet been found practical, due primarily to the lack of an entirely suitable tent material. A second scheme, which appears at first glance to possess fundamental merit, has been used commercially to a limited extent. This is the system known as "interval shooting," in which the fumigant is introduced in two (or more) individual portions, with a chosen time interval between the additions

SOME POSSIBLE ADVANTAGES AND DISADVANTAGES OF INTERVAL SHOOTING. Apparently the object of interval shooting is to maintain a more uniform concentration during the fumigation period than is obtained by the usual method. This should be of advantage if a given quantity of hydrocyanic acid will give a better scale kill when applied in this manner, or if tree tolerance is increased so that a larger amount of fumigant may be used without causing injury to the tree or fruit. Although the question of increased tree tolerance remains debatable, due to the great number of uncontrolled variables, the general opinion is that there is little difference in this respect. Likewise there is some diversity of opinion as to the comparative toxicity toward scale of equal amounts of hydrocyanic acid used in the regular way and in interval shooting. Again the concensus of opinion seems to be that there is little to choose between the two methods, with any advantage lying on the side of the regular method. Gray and Kirkpatrick[1] have shown that if black or red scale are first exposed to a sub-lethal, but stupefying, concentration of hydrocyanic acid in air, followed by a normally lethal concentration, more of them are able to survive than in the absence of the first treatment. Similar results have been obtained by Pratt, Swain and Eldred.[2]

This "protective stupefaction" is sometimes presented as an argument against double shooting, on the basis that this phenomenon would not occur in the regular (single shot) method but might be effective in the case of interval shooting. In interval shooting, however, the first shot is designed to produce a lethal concentration, and the object is to maintain such a concentration for as long a period as possible. It

[1]J. Econ. Entomol. 22, 878 (1929).
[2]J. Econ. Entomol. 24, 1041 (1931).

seems questionable whether protective stupefaction would be more in evidence in one method than in the other.

THE FACTOR OF "CONCENTRATION x TIME." The toxic effect of a given concentration of hydrocyanic acid will probably not be accurately

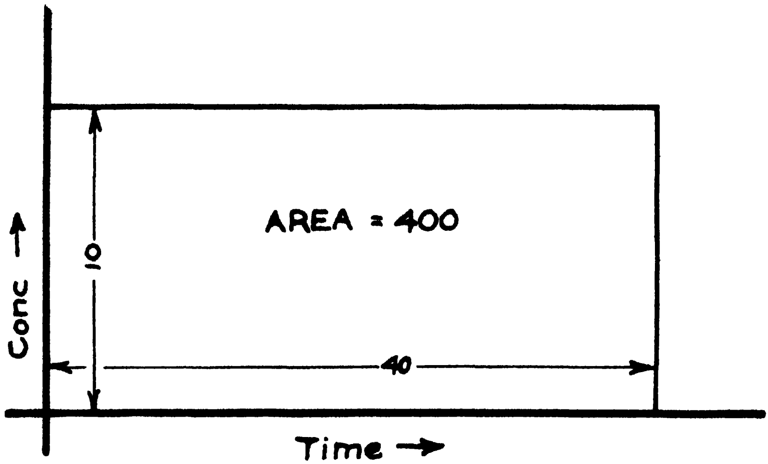


FIG 18

proportional to the product of this concentration and the time of exposure. However, this relation will probably hold in a qualitative manner, and by making such an assumption it is possible to draw

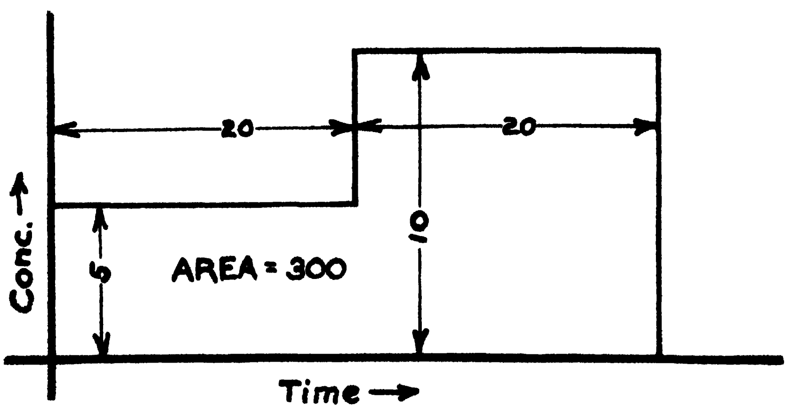


FIG. 19

interesting conclusions in regard to the probable relative effectiveness of interval shooting. In the arguments which follow it is intimated that the effectiveness of a fumigation may be judged by the integral of the

product of concentration and time, irrespective of the form of the concentration-time relation This may be in error, as there is need for experimental work in the comparison of concentration-time curves of varying form

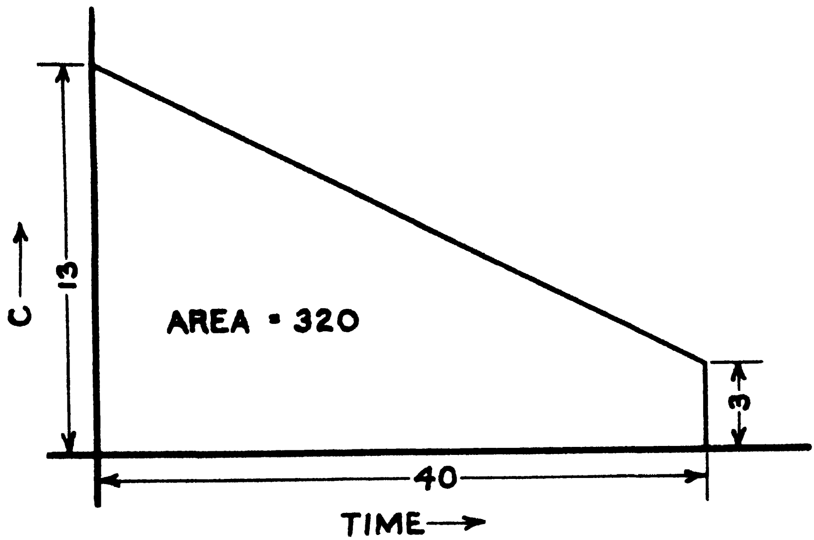


FIG 20

Let us first consider Figures 18 and 19 Figure 20 represents a plot of concentration vs time, assuming. (1) Initial introduction of 10 units of hydrocyanic acid (2) No loss (3) Removal of the tent after 40

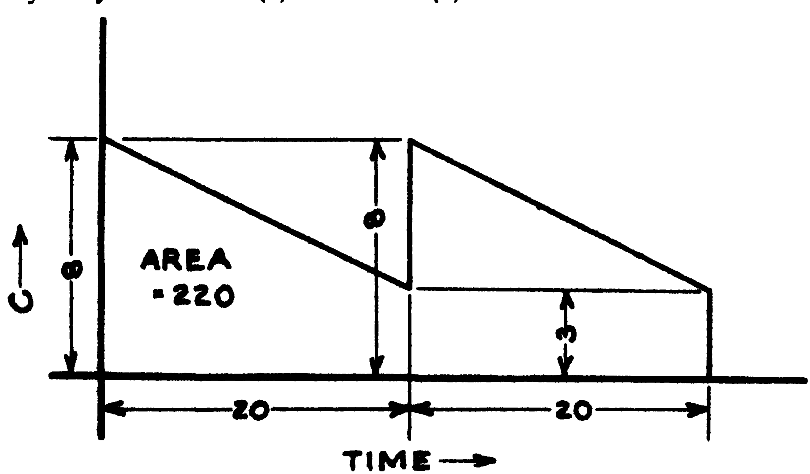


FIG. 21.

minutes. The rectangular area (A = 400 units) will represent the integral of concentration x time. Figure 19 represents the plot of concentration vs. time, assuming: (1) Initial introduction of 5 units, followed by an additional 5 units after twenty minutes (2) No loss. (3) Removal of the tent after 40 minutes. The area of the two rectangles (A = 300 units) will represent the integral of concentration x time during the entire 40 minutes of treatment It is apparent that this

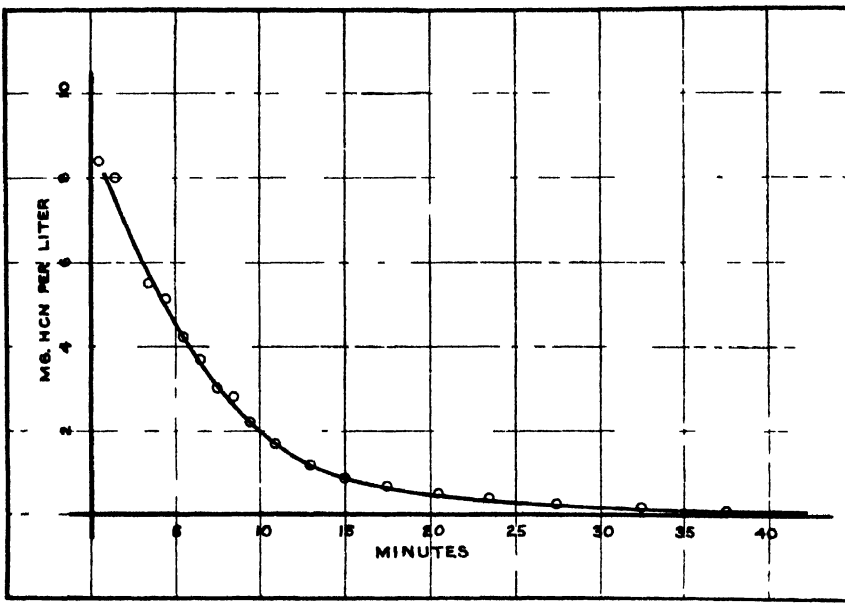


FIG. 22

second method of treatment will be less effective than the first method, if the toxic effect is proportional to the integral of concentration x time.

Let us next consider Figures 20 and 21. The first represents a plot of concentration vs. time, assuming: (1) Initial dose of 13 units. (2) Uniform decrease of concentration at the rate of one-fourth unit per minute, reaching the value of 3 at forty minutes, when the fumigation is stopped. The integral of concentration x time in this case amounts to 320 units. Figure 21 represents an imaginary interval fumigation using a total of 13 units of fumigant, as in the preceding case, and involves the following assumptions: (1) Initial dose of 8 units, followed by an additional 5 units after 20 minutes. (2) Uniform rate of decrease of concentration throughout, at the same rate as in the preceding case. In this second case the integral of concentration x time amounts to but 220

units, compared to a value of 320 units when the entire amount of fumigant is introduced at one time.

CONCENTRATION-TIME RELATION FROM FIELD TESTS. It is rather easy to assume that interval shooting will reduce leakage losses and consequently increase the value of $\int$ concentration x time, but the illustrations given above show that this conclusion may be in error. The advantage of one method over the other, in this respect, might con-

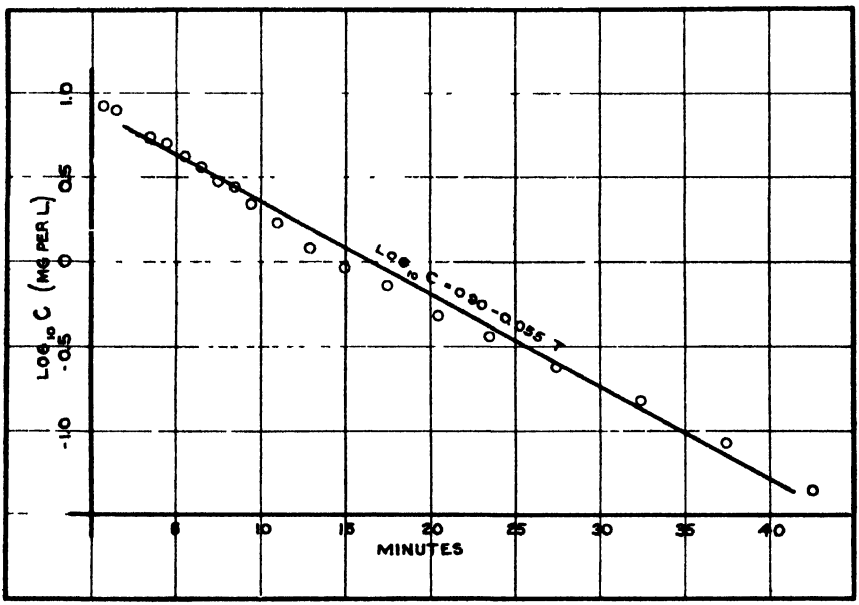


FIG. 23.

ceivably depend upon the actual form of the concentration-time curve which is obtained in field work. Accordingly let us consider some data which have been obtained in field tests.

Figure 22 presents a plot of concentration vs. time, representing data obtained during a field fumigation. Figure 23 shows the same data plotted as Log Concentration vs. time, and from this plot it appears that the data may be approximately reproduced by an equation of the form:

$$\text{Log C} = a - bt \tag{1}$$

in which Log C = common log of concentration, at time t
t = time, in minutes
a, b = empirical constants

As simple theoretical considerations also indicate a relation of the same general type, let us assume that an equation of the described form will express the relation between concentration and time for a series of comparable field fumigations. From Equation (1):

$$C = 10^{(a-bt)} \tag{2}$$

$$\int_{t=x}^{t=y} \text{Concentration x time} = \int_{t=x}^{t=y} 10^{(a-bt)}\,dt =$$

$$\left[\left(\frac{10^{a}}{2.3\,b}\right)\left(1 - 10^{-bt}\right)\right]_{t=x}^{t=y} \tag{3}$$

Taking b = 0.055, as found from Figure 23, this integral may be evaluated for any assumed values of "a" and "t" A number of such calculations have been made in which it has been assumed that two additions of hydrocyanic acid totaling 10 units are made, the second fifteen minutes after the first; the ratio of the amounts introduced at the first and second additions is assumed to range from 10:0 to 4:6. The results of these calculations are summarized below:

First Addition	Second Addition	$\int_{0}^{40} C\,dt$
10.	0.	78.6
8.	2.	78.0
6.	4.	77.4
4.	6.	76.9

Calculations have also been made for the purpose of comparing the values of $\int C\,dt$ which result from assuming different time intervals between two additions of six units and four units, respectively. The results are summarized below:

Minutes Between Additions	$\int_{0}^{40} C\,dt$
0.	78.6
3.	78.5
7.	78.3
15.	77.4

It is also of interest to note the case in which the fumigations are not stopped at the arbitrary time limit of forty minutes, but are allowed to continue until the hydrocyanic acid has been entirely dissipated. Under such circumstances the integral of the product of concentration and

time will be obtained by integrating to the final time limit of "infinity," and as long as such a fumigation involves a total of 10 units of fumigant, the integral will amount to the constant value of 79.1. This will be true irrespective of the time interval between the individual additions of fumigant, or the relative sizes of these additions.

All of the given results indicate that there is nothing to be gained by interval shooting from the point of view of obtaining, from a given amount of fumigant, a maximum value of $\int C\,dt$. Any advantage which it may possess must lie in some other effect, at present undemonstrated, which might be due to the particular form of the concentration-time relation.

ACKNOWLEDGMENT. The author wishes to thank Dr. R. C. Roark for his helpful suggestions and criticism of this manuscript.

SOME METHODS USED IN TESTING CATTLE FLY SPRAYS[1]

By A. M. PEARSON, J L. WILSON and C. H. RICHARDSON, *Iowa State College, Ames, Iowa*

ABSTRACT

Existing methods of testing cattle fly sprays for repellent efficiency on the stable fly, *Stomoxys calcitrans* (L.), are unsatisfactory. A method, which consists essentially of making close observations on sprayed cows of previously determined fly susceptibility, gave much better results. Thirty-five selected cows were used in determining the relative efficiency of 6 fly sprays. The cows were scrubbed with soap and water, then staked individually in a pasture, being removed only for watering and milking. The normal fly susceptibility of each cow was obtained from the average of two counts of the number of flies present, made hourly from 7 a.m. till 3 p.m. for a period of 3 days. The cows were then placed in 7 groups of 5 each, the maximum difference in the number of flies per cow per count between the groups being about two. The 6 spray materials were then assigned by chance to each of 6 groups of 5 cows; the remaining group served as the control. Each cow was sprayed at 6 a.m. daily for 4 consecutive days with 2 fluid ounces of spray material applied with an electric sprayer. The fly susceptibility of the sprayed and control cows was determined as before. The results show that close individual observations of a relatively few cows of known fly susceptibility give more consistent and dependable results than less accurate observations on a large number of cows. The population of stable flies on unsprayed dairy cattle increases from 7 a.m. till about mid-day after which it tends to become stationary.

The increasing economic status of cattle sprays has been discussed by

[1]Journal Paper Number B64 of the Iowa Agricultural Experiment Station.

Cleveland[2], Freeborn, and Regan[3] and others. A more concrete example of the financial value of cattle sprays may be obtained by calculating an approximation of the actual cost of the sprays used. It would cost, for spray material alone, to spray the cows kept for milking purposes in Iowa in 1929[4] no less than $10,500. This is calculated on the basis of one application of a minimum dose of 1 ounce per cow of a commercial spray material retailing at the conservative price of $1.00 per gallon. On this same basis it would cost the twelve Central States approximately $90,000 for one application of spray, and the United States over $173,000. Although these estimates are for only one application of spray, it is a well known fact that the fly season, especially throughout the Central States, is of three months' duration.

Industrial concerns have not been entirely unaware of this aspect of oil spray materials. Information in the hands of the authors shows that considerably more cattle spray research has been sponsored by industrial manufacturers than has been indicated by publications. This is largely due to the necessity of the concern to keep its formulas more or less secret for competitive reasons. Without reflection on previous investigations in cattle spray research, it is safe to say that much is yet to be desired in practical quantitative studies on this subject. The methods and data given herein are presented with the hope that they may be of value in helping future workers avoid mistakes similar to those made by the authors; and that possibly some methods of attack not previously given in the literature may be mentioned.

For three months during the summer of 1931, the authors were actively engaged in a cattle spray project at Iowa State College. In brief, the purpose of the project was to test the relative merits and practicability of several newly developed formulas under the headings: skin injury; physiological effects; fly repellency, and toxicity.

The more detailed description of the phases of the work on skin injury and physiological effect will be found in another publication.[5] It was found that caliper measurements of skin thickness could not be definitely correlated with the beginning of obvious skin injury. All the sprays produced a very slight increase in the average body temperature of the cows but no dangerous abnormalities resulted from their use.

[2]Cleveland, C. R. Repellent Sprays for Flies Attacking Dairy Cattle. Jl. Econ. Ent. Vol. 19, No. 3, pp. 529–536. 1926.

[3]Freeborn, S. B. and Regan, W. M. Fly Sprays for Dairy Cows. Jl. Econ. Ent. Vol. 25, No 2, pp. 167–174. 1932. [4]U. S. Dept. Agric. Yearbook, 1928.

[5]Paper by Wilson J. L., Pearson, A. M. and Cannon, C. Y., in press in Jl. Dairy Science.

The data obtained were of no particular value from the standpoint of toxicity. This subject might be studied to better advantage in the laboratory rather than under field conditions.

The predominating species of fly encountered was the stable fly, *Stomoxys calcitrans* (Linn.). The house fly, *Musca domestica* Linn., was for the most part noticeable only in or very near the barns. The horn fly, *Haematobia irritans* (Linn.), did not occur in appreciable numbers throughout the summer. A very few were observed for about a week in June and again in September.

Six herds, totalling 150 cows, located in the vicinity of Ames, Iowa were sprayed daily. A competent livestock judge was engaged to group these cows into approximately equal groups on the basis of color, size, lactation and age.

Each group was assigned an oil by chance. Each material was sprayed in two different herds, and a control spray was used in each herd. Three herds were sprayed each morning and three each afternoon. The groups were so divided that each oil was sprayed both morning and afternoon

Two types of sprayers were used. Electric sprayers, driven by small motors, and delivering approximately one fluid ounce per minute of 85 viscosity oil, were used on four herds The hand sprayers, with which the remaining two herds were sprayed, were of one-gallon capacity, and operated best when about half full. They were designed to give a continuous spray while in operation The electric sprayers were much the more accurate in delivering exact amounts of spray material on each cow. This was due to the fact that an ordinary fruit jar could be used as the container. Each jar was graduated and the approximate amount being sprayed could be easily and quickly observed. A separate fruit jar was employed for each spray material to facilitate ease and speed when changing from one material to another. Two fluid ounces (approximately 60 cc.) per cow were applied with the electric sprayers and two and one-half ounces with the hand sprayers. This difference in the quantities of material seemed to be necessary in order to apply the same amount of solution on each cow Each spray material was applied with both electric and hand sprayers.

Two separate methods were used to determine relative fly repellency. The first method has been commonly employed by other workers. It consists of making hourly fly counts on each herd on the same day. Theoretically, the tabulated results should indicate the relative fly repellency of the materials used. Several observations of this kind were made. The cows were marked with numbered tags on insulated wire

collars, and were permitted to follow their usual routine of grazing in the pasture or loitering near the barn. Upon comparing the data obtained in this manner at several intervals of time from the six herds it was evident that this method gave very inconsistent results. The normal fly susceptibility of individual cows appeared to be a very important and variable factor. It was unsatisfactory to have the cows run free as they have a marked tendency to rub against each other and to maintain a changing environment from the standpoint of fly population.

The second method used proved to be much more consistent and satisfactory. For various reasons, the spray materials were reduced to six in number. Thirty-five cows were selected for use at the Iowa State College Dairy Farm. These cows were thoroughly scrubbed with soap and water, and were staked individually in a small pasture throughout the duration of the test, being removed only for watering and milking. The normal fly susceptibility for each cow was determined by making hourly counts for three days previous to the application of the spray solutions. With this normal susceptibility data in hand, the cows were divided into seven groups of five cows each. The cows were so grouped that the average normal number of flies attacking each group varied only about two flies per cow. Six groups of five cows were selected at random, a spray material being assigned by chance to each; the remaining group served as the control. The cows were sprayed at 6:00 a.m. each day with two fluid ounces of spray material applied with the electric sprayers. They were kept staked individually and treated for four consecutive days in this manner. Two fly counts were made for each hour from 7:00 a.m. to 3:00 p.m. inclusive, and the average of these two counts was recorded as the actual observation for each hour.

TABLE 1. EFFECT OF OIL SPRAYS ON THE AVERAGE NUMBER OF FLIES PER COW PER COUNT

Spray formula number	Number of cows	Av. number of flies per cow per count: 3 days with no spray	Sprayed 4 days	Percentage efficiency
1	5	52.0	19.1	63.6
2	5	53.8	22.9	58.1
3	5	53.6	23.8	56.2
4	5	54.2	25.1	55.0
5	5	54.0	28.5	45.0
6	5	54.6	29.6	43.0
Control.......	5	53.6	53.1	——

NOTE—The petroleum oils which formed the basis of these sprays had with one exception a viscosity of 80 to 85 seconds (Saybolt at 100° F.), and an unsulfonated residue of approximately 70%. The viscosity of the oil in spray No. 4 was 55 to 60 seconds. Sprays No. 2 and 4 contained the same added repellent ingredient; each of the other sprays contained a different repellent. The added toxic ingredient was the same in all sprays but spray No. 1 contained twice the quantity of the other sprays.

A summary of the fly repellency data obtained in this manner is given in Table 1.

Figure 24, A shows the trend of the normal average fly population throughout the day for unsprayed cows; Figure 24, B shows the percentage efficiency of the spray materials used. Freeborn and others[6] have stated that the stable fly does not congregate on the animals and usually feeds only once a day, generally in the morning. The hourly trend of the actual number of flies present on the unsprayed cows (Fig. 24, A)

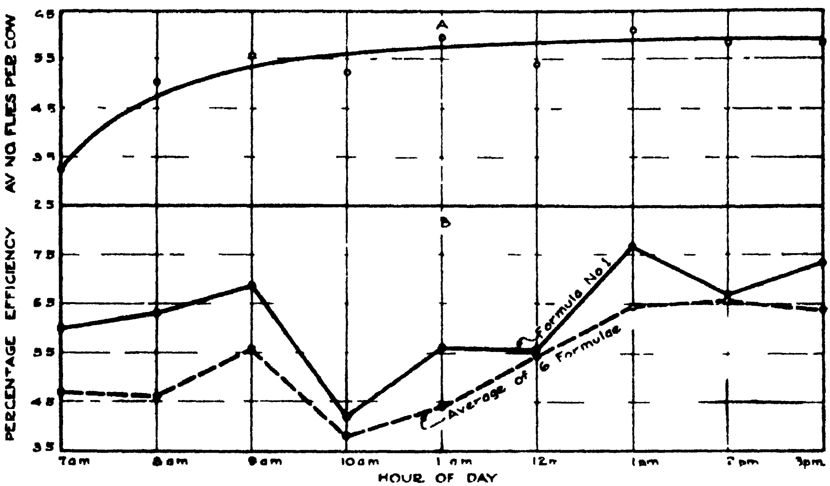


Fig. 24.—A Average fly population on 35 unsprayed cows for 3 consecutive days. Control. B. Average percentage efficiency of sprays for 4 consecutive days. Control = 0 efficiency.

does not show any indication of this condition. On the other hand, there appears to be a gradually increasing population of flies on the cows until the early afternoon when the population tends to become nearly stationary. The stable fly was the predominating species present during the course of these observations. It is interesting to note that the efficiency of all the sprays showed a definite decrease between the hours of 9:00 a.m. and 11:00 a.m. This might be interpreted as the period during which the flies actually feed, and correspondingly the period in which they are most difficult to repel. Contrary to expectation, all the sprays showed as great, or greater, efficiency in the afternoon as during the forenoon hours. This again might be explained on the grounds that the flies perform most of their feeding during the forenoon hours, and

[6]Freeborn, S. B., Regan, W. M., and Folger, A. H. The Relation of Flies and Fly Sprays to Milk Production. Jl. Econ. Ent. Vol. 18, No. 6, pp. 779–790. 1925

that they are more easily repelled in the afternoon when their hunger has been largely satisfied.

ACKNOWLEDGMENTS. This project was made possible by a fund established by the Standard Oil Company of Indiana. All necessary equipment and spray materials were furnished by this company. To Messers C. R. Cleveland, E. H. Hillman, and H. J. Saladin of the Standard Oil Company of Indiana we are indebted for generous cooperation and assistance throughout the duration of this project. Dr. C. Y. Cannon, Dr Dwight Espe and Professor E. N. Hansen of Iowa State College aided materially and offered many helpful suggestions.

RELIABILITY OF DIFFERENCES BETWEEN DATA OBTAINED IN COTTON INSECT INVESTIGATIONS

By J. C. GAINES, *Entomologist, Texas Agricultural Experiment Station*

ABSTRACT

A statistical comparison is made of methods used in taking cotton insect infestations and methods used in obtaining data on the growth of cotton plants in experimental plats.

Field entomologists, in collecting data on their respective projects, are confronted with the problem of obtaining the most accurate sample of the population. Usually there are several ways of collecting samples, and by using biometrical methods the most accurate sample can be ascertained. It is not the intention to deal with all the biometrical methods, but to present certain data obtained in cotton insect investigations where it is desirable to determine the significance of the mean difference between two samples.

The test to apply to a difference depends on the method of sampling and other information in the form of numerical measures concerning the variables under discussion. Probably the most common type of difference to be tested is the mean difference between two samples, each of which is drawn from a similar population, but no one item in one sample can be sensibly related to any specific item in the other. Under this condition, probable error, standard error, or standard deviation of the mean difference takes the form of $\sigma_D^2 = \sigma_1^2 + \sigma_2^2$. This value, σ_D^2 when divided by n[1] gives the standard error of the difference or the standard deviation of the mean difference. The probable error of the mean difference can be found by simply multiplying by .6745. From the ratio of the mean difference to the measure of reliability, the probability

[1]n-1 is used instead of n in getting standard deviation.

of this difference being due to chance and also the odds against a difference as great or greater occurring due to chance can be read from Pearl's[2] prepared probability tables. To be sure that a difference is not due to chance, the coefficient of odds $\frac{\text{(Mean difference)}}{\text{(error of the mean difference)}} = \frac{M_D}{E_D}$ should be four or more.

Fisher[3] gives a method for testing the mean difference in which the number of individuals are considered and also allows for degrees of freedom. The reliability of the mean difference can be tested by the use of the prepared tables of t. For any degree of certainty from this table, a high value of t is required with a small value for n.

These two methods of testing the reliability of a difference are compared, using data obtained in taking boll weevil infestation records. The point and survey methods were used to obtain the infestation on 1,034 acres of cotton on the same date. The point method consisted of examining 100 squares at 36 different points. This was a point to about every 29 acres. The survey method consisted of examining from 25 to 50 squares at 378 points while walking through the cuts in a somewhat circling course. This was a point to about every 2 acres. The survey method required more work than the point method but enabled one to see what the infestation was on every 2 acres of the entire plantation.

Using the first method to test the reliability of the difference between these two methods of taking the boll weevil infestation·

Sum of the per cent punctured squares in point method = S X = 1374

Sum of the per cent punctured squares in survey method = S Y = 13965

Number of items in point method = n_x = 36

Number of items in survey method = n_y = 378

Deviation of X item from its mean = x

Deviation of Y item from its mean = y

Standard deviation = σ

Mean difference = M_D = 1.22

$$\sigma x = \sqrt{\frac{Sx^2}{n_x - 1}} = \sqrt{\frac{6051.09}{35}} = \sqrt{172.89} = 13.15$$

$$\sigma_y = \sqrt{\frac{Sy^2}{n_y - 1}} = \sqrt{\frac{127806.45}{377}} = \sqrt{339.01} = 18.41$$

[2]Pearl, R. Medical Biometry and Statistics. 2nd Ed. W. B. Saunders Company, 1930.

[3]Fisher, R. A. Statistical Methods for Research Workers. 3d Ed. Oliver and Boyd, Edinburgh, 1930.

$$\sigma_D = \sqrt{\sigma_x^2 + \sigma_y^2}$$

$$\sigma_D = \sqrt{172\ 89 + 339\ 01} = 22\ 62$$

Probable error of the difference $= E_D = \dfrac{22\ 62}{\sqrt{414}} \times 6745 = 75$

Cofficient of odds $= \dfrac{M_D}{E_D} = \dfrac{1\ 22}{75} = 1.63$

From Pearl's prepared tables the coefficient of odds, or 1 63, has the odds of 2.5 to 1 against the occurrence of a deviation as great or greater than this due to chance The probable occurrence of a deviation as great or greater than this might be expected to be about 28 out of 100 trials, due to chance alone

Using Fisher's method for testing the reliability of this difference, the sum of the squares are pooled together and from this the standard deviation is found

The pooled standard deviation

$$\sigma = \sqrt{\frac{Sx^2 + Sy^2}{(n_x - 1) + (n_y - 1)}} = \sqrt{\frac{6051\ 09 + 127806\ 45}{412}} = 18\ 02$$

The standard deviation divided by the pooled number = standard

$$\text{error} = \epsilon = 18\ 02\sqrt{\frac{1}{n_x} + \frac{1}{n_y}} = 18\ 02\sqrt{\frac{n_x + n_y}{(n_x)\ (n_y)}} = 3\ 14$$

$$t = \frac{M_D}{\epsilon} = \frac{1.22}{3.14} = .388$$

In this problem the number is 412 and the t value is 388 For this value of t the probability of this difference occurring due to chance is about 7 out of 10 trials

The results from both statistical analyses show that the mean difference between the two methods used to take the boll weevil infestation is not significant At later dates during the summer both methods were used to take the infestation again, and the analyses of the data showed similar results.

Another application of a reliability measure of a difference suggests a different method of sampling This measure requires that a given item of X sample bears a given relationship to a certain item in Y sample; that is, the variates are paired Under this condition of sampling the measure of reliability of a difference is $\sigma_{x\ y}^2 = \sigma_x^2 + \sigma_y^2 - 2r_{xy}\,\sigma_x\,\sigma_y$.

This will give a smaller value for the reliability measure and a greater coefficient of odds when the value of r is positive. After this formula has been applied the error can be obtained as before and Pearl's probability tables can be used to test the reliability of the difference.

Fisher also gives a method for testing the reliability of a difference when the variates are paired.

The two methods of testing the reliability of a difference are compared, using data obtained in taking cotton flea hopper population records. The method used by some entomologists to keep up with the cotton flea hopper population is as follows: In the early spring when the cotton is small, the top buds of 100 cotton plants are examined and the number of nymph and adult flea hoppers recorded; later in the season 100 sweeps are made over the tops of the cotton plants with a standard insect net and the number of nymph and adult flea hoppers recorded. These two methods were used to get the flea hopper population on the same date at the same point in several cotton fields to obtain some data that could be used in a statistical comparison.

To test the reliability of the difference between the two methods of getting the cotton flea hopper population:

Sum of the number insects sweeping method = SX = 458
Sum of the number insects examination method = SY = 558
Number items in sweeping method = n = 26
Number items in examination method = n = 26
Deviation of X item from its mean = x
Deviation of Y item from its mean = y
Mean difference = M_D = 3.85
Standard deviation = σ
$\sigma x = 10.35$
$\sigma y = 16.43$
Correlation coefficient = $r_{xy} = .879$

$$\sigma_{x-y}^2 = \sigma_x^2 + \sigma_y^2 - 2r_{xy}\,\sigma_x\,\sigma_y$$
$$= 107.04 + 269.94 - 2(.879)\,(10.35)\,(16.43)$$
$$= 78.03$$

This σ_{x-y} can also be calculated from the series of differences between paired items.

$$\text{Probable error of the difference} = \frac{8.83}{\sqrt{26}} \times .6745 = 1.17$$

$$\text{Coefficient of odds} = \frac{M_D}{E_D} = \frac{3.85}{1.17} = 3.29$$

From Pearl's prepared tables, the coefficient of odds, or 3.29, has the odds of 37 to 1 against the occurrence of a deviation as great or greater than this due to chance. The probable occurrence of a deviation as great or greater than this might be expected to be about 2.6 out of 100 trials, due to chance.

Using Fisher's method for testing the reliability of this difference:

The standard deviation of the difference $= \sigma_{x\ y} = 8.83$

The standard deviation of the difference divided by the square root of

$$\text{the number} = \epsilon = \frac{8.83}{\sqrt{26}} = 1.73$$

$$t = \frac{M_D}{\epsilon} = \frac{3.85}{1.73} = 2.22$$

From the prepared table of t values, when the number is 25 and the t value of 2.22, the probability that this difference will occur due to chance is between 2 and 5 times out of 100 trials.

The results from both statistical comparisons give practically the same odds against this difference being due to chance. Judging from these data, it cannot be stated that the number of insects taken in the 100 sweeps represents the number of insects in the tops of 100 cotton plants. A smaller number of insects is captured by taking 100 sweeps than is recorded by examining 100 cotton plants. This comparison shows that the sweeping records do not represent as good a sample of the population on 100 plant tops as the examination record.

In cotton insect investigations, three plat cuts are used to test the efficiency of different poisons. Each cut consists of three acre-sized plats, about 30 rows wide, carefully selected for uniformity. The growth of the cotton on these plats is obtained by measuring plants in each plat at regular intervals during the season. These records are usually obtained by measuring 100 plants at each of three points, at each end and in the middle of each plat, and an average recorded. The problem here is to determine if the time required to get these records can be reduced by measuring only 100 plants in the middle of each experimental plat.

To test the reliability of the difference between the average height of 100 plants at each of three points in the plat, and the average height of 100 plants in the middle of each plat:

The standard deviation of the difference $= \sigma_{x\ y} = .55$

The standard deviation of the difference divided by the square root of

the number $= \epsilon = \dfrac{.55}{\sqrt{13}} = .15$

$$t = \frac{M_D}{\epsilon} = \frac{.15}{.15} = 1.00$$

In this problem the number is 12 and the t value is 1.00. For this value of t the probability of this difference occurring due to chance is about 3 out of 10 trials. The mean difference between these two methods of taking the plant heights is not significant. This comparison is not to determine the best method for taking the plant height records, but merely to test the reliability of the difference between methods that are in use at the present time by some entomologists.

Summary

1. The mean difference between the point and the survey methods used to take the boll weevil infestation is not significant.

2. The mean difference between the sweeping and examination methods used to take the cotton flea hopper population is significant. Judging from these data, the number of insects taken in 100 sweeps is not as good a sample of the population in the buds of 100 plants as the number of insects recorded by the examination method.

3. The mean difference between the average plant height records taken on 100 plants at each of three points and the average plant height records taken on 100 plants at one point in experimental plats is not significant.

SHIPPING ADULT INSECT PARASITES IN REFRIGERATED CONTAINERS[1]

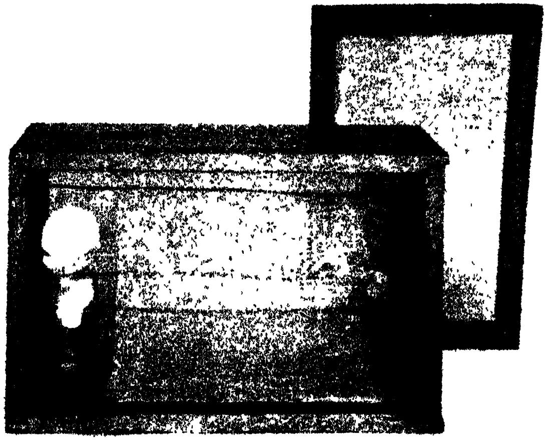
By J. K. HOLLOWAY, *U. S. Bureau of Entomology*

ABSTRACT

A refrigerated container devised to decrease the mortality in shipments of parasites has been used successfully in transporting frail adult stages of several species of parasites of the oriental fruit moth (*Grapholitha molesta* Busck) to practically all of the peach-growing centers in the eastern part of the United States. The shipments were made throughout the entire summer of 1931. The average consignment was in transit 50 hours, and the average mortality of *M. ancylivorus* Roh. shipped under such conditions was only 1.4 per cent.

During 1930 and 1931 numerous shipments of adult parasites of the oriental fruit moth were made from Moorestown, New Jersey, to many peach-growing districts in the eastern part of the United States. These were made during the summer months when the high temperatures were unfavorable for the transportation of adult insects. In order to overcome this adverse condition it became necessary either to utilize a very rapid means of transportation or to use refrigeration. The use of air mail and air express was impracticable because most of the consignments were made to rural communities remote from airport centers, and considerable time would have been lost in making changes to other means of transportation. It was impossible to take advantage of refrigerated cars because there was no regular scheduled service south and west from Philadelphia. The shipments of parasites by railway express were in transit on an average 50 hours. This included some of the more distant consignments to Michigan, Missouri, Arkansas, and Georgia. Railway express proved to be the most suitable means of transportation because a scheduled service is maintained, and agencies for delivery are widely distributed.

To utilize these facilities it was necessary to devise a container that would provide and maintain for 50 hours a lowered temperature that would be favorable to the adult parasites. The equipment and assembly used in the shipping container were as follows: A maximum of 500 adults were confined in wooden cages having a capacity of 300 cubic inches. (Plate 9.) The cages were provided with a water bottle stoppered with a cotton plug covered with gauze. The water was fed to the stopper by a gauze wick. About 1 gram of food made of honey and sugar was supplied, the quantity of sugar being sufficient to make the mixture almost dry. The surface area within the cage was increased by tacking cloth to opposite sides and weaving it between three wire supports. A maximum



Unit cage

Complete assembly.

of four such cages were packed with dry sphagnum moss in a metal cylinder with a tight-fitting telescopic lid. The cylinder was placed upright in a 40-quart ice cream shipping tub. (Plate 9.) Eight inches of sawdust was placed in the bottom of the tub before any ice was added. This is done to prevent stratification of the air within the cylinder so that there will not be too great a difference in temperature between the top and bottom of the container. The ice was cracked as large as possible and mixed with sawdust to prolong refrigeration and avoid too low a temperature resulting from rapid melting. The container, completely packed, 50 pounds of ice being used, had an average gross weight of 145 pounds.

It had been previously determined that temperatures from 45° to 50°F. served to render adults inactive but not to the point of complete immobility. Under such conditions it has been found that the longevity of adults of *M. ancylivorus*, and of several other parasites of the fruit moth, was greatly extended, and that when such adults were again exposed to higher temperatures they reacted normally in every respect. A test was made of the temperatures existing in a refrigerated shipping container under average shipping conditions. Temperature readings were obtained by thermocouple, without disturbing the setup. These readings, given in Table 1, indicate that for the greater part of the 55 hours during which the readings were obtained the temperature of all parts of the refrigerated portion was within a desirable range for the cold storage of adult parasites, the temperatures lying between 40.0° and 60.7° F.

TABLE 1. TEMPERATURE READINGS OBTAINED IN A REFRIGERATED SHIPPING CONTAINER

Number of hours after the container was packed	Room temperature	Temperature in cage at the top of the cylinder	Temperature in cage at the bottom of the cylinder
	°*F.*	°*F.*	°*F.*
1	76	41.7	43.0
3	74	40.0	41.0
6	75	40.0	41.0
22	75	42.9	42.4
30	85	45.0	44.0
48	73	60.7	47.4
55	69	59.7	50.3

Another experiment was conducted in which two colonies of 1,000 adult *M. ancylivorus* were packed and allowed to remain unmolested for 60 hours. When the container was unpacked the temperature in the cylinder was 44° F. There was no mortality, and the parasites were successfully used in propagation.

During the summer of 1931 many thousand adult parasites were shipped by railway express in these containers. *M. ancylivorus* is used as an example of the results obtained because this species was shipped throughout the entire season to practically all of the peach-growing states east of the Mississippi River. It was subjected to the greatest variations of temperature and time in transit. A total of 41,700 adults were shipped. The highest mortality was 5.8 per cent, the lowest 1 per cent, and the per cent total mortality was 1.4. A few shipments were made which required 24 hours or less to reach their destination. In such cases refrigerated containers were not used but the unit cages were shipped in wire-covered crates in which they were imbedded in moist sphagnum moss. The average mortality in these unrefrigerated shipments was 12.3 per cent.

Refrigerated containers were successfully used to transport Glypta, Pristomerus, and Ascogaster. They were also used to transport imported parasite material from the Port of New York to Moorestown, New Jersey. They mark a distinct improvement in method over shipment in the sphagnum-packed crates previously used[1] and have proved so useful and efficient that they will in the future be used for our shipments of adult parasites requiring more than a few hours in transit.

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1. Allen, H. W. 1931. The Mass Production of *Macrocentrus ancylivorus*, a Parasite of the Oriental Fruit Moth, and Its Distribution from Southern New Jersey. Jour Econ. Ent. vol XXIV, No 1, p. 309.

DRAECULACEPHALA MOLLIPES SAY, A CICADELLID PEST OF APPLES

By P. W. Claassen, *Ithaca, N. Y.*

Abstract

An account of the injuries caused to the fruit and twigs of the apple, by crescent-shaped oviposition punctures of the sharp-nosed leafhopper, *Draeculacephala mollipes* Say.

The females make a crescent-shaped cut, 3-4 mm. long, through the skin of the apple or twigs and deposit from a few to more than twenty eggs within each egg puncture. As many as 125 egg punctures have been found on a single apple. The injury is largely restricted to the fruit and twigs on the lower portion of the tree.

In October 1931, many apples on the trees of the Cornell University Experiment Station orchard were found to contain injuries of a type not

[1]Contribution of the Oriental Fruit Moth Parasite Investigations.

heretofore reported on apples. These injuries, which on superficial examination seemed to be of a mechanical nature, appeared as small crescent cuts on the fruit, quite suggestive of fingernail cuts. That is to say it appeared as if a small child might have repeatedly dug its fingernails into the apple and thus broken the skin in many places. On closer examination, however, these crescent cuts were found to be egg punctures which contained elongate insect eggs about one millimeter in length.

A search around the trees revealed the presence of many green leafhoppers, *Draeculacephala mollipes* Say, and before long a female was observed on the apple in the act of oviposition. Later many more females were found ovipositing, both on the apples and on the twigs. The female pushes her sword-shaped ovipositor into the apple and then begins to saw a crescent-shaped cut through the apple. After part of the cut has been made she pushes her ovipositor in as far as it will go and lays an egg In a few moments she lays another egg and so on until a series of eggs has been laid in the pocket. The cut, made by the ovipositor, varies from 3 to 4 mm. in length. The puncture on the twig is made similarly to that on the fruit but due to the hardness of the wood the ovipositor does not penetrate farther than to the cambium layer. Most of the oviposition punctures on the twigs are made on the two, three and four-year old wood and the egg pockets are very noticeable by the manner in which they bulge out

During oviposition the female pushes her ovipositor out to one side and after bracing herself she begins to push the ovipositor through the epidermis, alternately pushing and pulling the blades of the ovipositor in a saw-like manner, until it reaches nearly its full length under the skin of the fruit More often the cut is directed to one side just under the skin so that the eggs lie in a horizontal position and may often be seen through the transparent skin of the fruit but sometimes the ovipositor goes straight down and the eggs are deposited deeper into the flesh of the apple and placed in a position perpendicular to the outer skin.

The number of egg punctures per apple varies from only one or two to as many as 125. Apples with 25 to 40 egg punctures were very common. On the twigs the punctures were quite abundant but never so numerous or so closely placed as on the fruit. From 5 to 7 egg punctures per linear inch of twig, however, was not uncommon. Many old egg punctures were observed and these indicate that the leafhoppers have been in this orchard for some years. The old egg punctures leave the twigs rough and badly scarred.

The leafhopper injury is largely restricted to the lower portion of the tree. The greatest number of egg punctures were found on apples and twigs within 2 to 4 feet off the ground. Once in a while an egg puncture was seen on the apples or twigs 5 to 6 feet above ground but not often. Although there were many apples lying on the ground under the trees it was very seldom that a leafhopper was observed ovipositing on these apples.

On the fruit the egg punctures are scarcely noticeable immediately after oviposition has taken place except for the slight bulge which may be noted in the shallower cuts. Soon after oviposition however the cut edges of the crescent begin to brown and to draw somewhat apart. On the twigs the new punctures are more noticeable. Apples with oviposition punctures are subject to rather rapid drying out and at ordinary room temperatures they begin to shrivel up very soon and this is followed by rotting. Several bushels of affected apples were stored in a storage house where the temperature is kept at about 33° F. Here the apple kept quite well during the winter months but by March 1st, many of them had begun to rot and fungus growth was noted in the oviposition punctures of most of the apples.

On the twigs the oviposition punctures leave bad scars and these persist for years.

The injury from these leafhoppers was observed on more than 30 varieties of apples and all of them seem to be equally susceptible to these insects.

Oviposition punctures were found on apples in six or seven orchards in the vicinity of Ithaca as well as in orchards in Ontario and Wayne Counties.

In all of the orchards where this leafhopper injury was observed the ground was well covered with grass and weeds.

Explanation of Plate 10

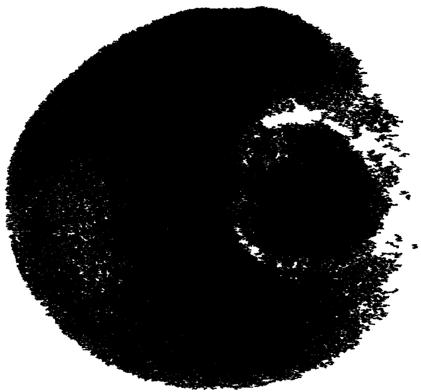
1.—Apple showing characteristic crescent-shaped egg punctures of *Draeculacephala mollipes*.

2.—Leafhopper ovipositing in the apples.

3.—Complement of leafhopper eggs which were laid under the skin of an apple twig.

4.—Egg-pocket and eggs of the sharp-nosed leafhopper. Egg-pocket at a.

5.—Old egg puncture scars on the twig of an apple.



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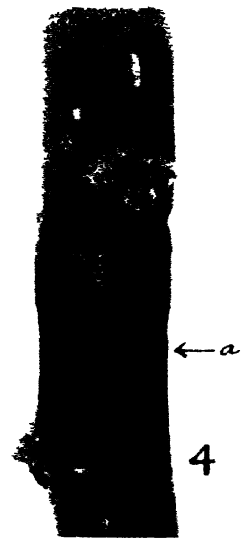

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THE TOXICITY OF CERTAIN PLANT EXTRACTS TO GOLDFISH.[1] II.

(Contribution from the University of Maryland Station of the Insecticide Division of the Bureau of Chemistry and Soils)

By Joseph R. Spies

Abstract

Further determinations of the toxicity to goldfish of acetone extracts of certain reputedly poisonous plants have been made. Preliminary determination of the toxicity to insects of the most promising of these extracts has shown that a few of them may possess considerable insecticidal value.

The examination of a large number of reputedly poisonous plants in the search for possible sources of valuable insecticides has led to the use of goldfish as a comparatively rapid and certain means of sorting the plants to show which of them possess sufficient toxicity to warrant further investigation. While it is probable that no direct correlation exists between the toxicity of plant extracts to goldfish and to insects, it is generally accepted that those substances which are toxic to insects will also be toxic to goldfish, although the reverse is not always true. These considerations, together with the fact that tests on fish are far easier to carry out and control and require less time than tests on insects, make goldfish particularly adaptable to a preliminary study of the possible insecticidal value of the plants.

The extracts used in this investigation were prepared exactly as described by Drake and Spies[2] in an article recording the results of a similar previous study. The toxicity tests were also carried out as there described.

The results of the tests are shown in Table 1, which also gives the Insecticide Division reference number (I D. number) of the plant. Further information concerning the origin and history of the plant materials can be obtained from the Insecticide Division of the Bureau of Chemistry and Soils by referring to the I. D number given In several cases only the common local name of the plant is given because it was impossible to determine the species from the material at hand.

For convenience the most toxic of the plants are listed in Table 2. Extracts of these plants caused death of the fish in one hundred minutes or less. A sample of derris root known to contain 1.7 per cent rotenone

[1]The plants used in this investigation were collected under the supervision of Dr. R. C. Roark of the Insecticide Division, and the author wishes to express thanks to him for the many helpful suggestions which he made during the course of the work.

[2]Drake and Spies, This Journal 25, No. 1, 129 (1932).

TABLE 1. TOXICITY OF ACETONE EXTRACTS* OF VARIOUS PLANTS TO GOLDFISH

Plant	I. D. No.	Part of plant tested	Where collected	When received	Survival time in minutes§
Amorpha fruticosa	714	whole plant	Western N. C.	June 1931	278
Amsonia tabernaemontana	721	whole plant	Western N. C.	June 1931	—
Annona cherimola	726	seeds of fruit	Lima, Peru	June 1931	220
Apocynum pubescens	720	whole plant in bloom	Western N. C.	June 1931	—
"Bejuco chilio"	843	stems	San Salvador	Jan. 1932	90†
Baptisia leucantha	731	whole plant	Columbia, S. C.	June 1931	—
Baptisia villosa	732	whole plant with seed pods	Columbia, S. C.	June 1931	—
"Barbasco"	793	————	Guatemala	Sept. 1931	256
Callicarpa cana	826	leaves, stems and berries	Manila, P. I.	Dec. 1931	163†
"Callo de Barbasco"	669	————	Guatemala	May 1931	serious distress
"Callo de Barbasco"	668	————	Guatemala	May 1931	1 dead; others in serious distress
Ceratiola ericoides	913	stems and a few leaves	Little River, Fla.	Mar. 1932	334; one in serious distress
Ceratiola ericoides	913	roots	Little River, Fla	Mar. 1932	slightly affected
Chrosperma muscaetoxicum	722	whole plant	Western N. C.	June 1931	some distress
Chrosperma muscaetoxicum	733	whole plant	Columbia, S. C.	June 1931	—
Cyclamen sp	792	corms	Greece	Aug. 1930	—
Cracca virginiana	829 (58)	roots	Milano, Tex	Dec. 1931	146†
Cracca virginiana	724	whole plants	Fountain Inn, S. C.	June 1931	167
Cracca virginiana	719	tops and blossoms	Hot Springs, N. C.	June 1931	2 dead; 2 in distress
Cracca virginiana	712	whole plant	Western N. C.	June 1931	147
Cracca virginiana	723	aerial with seed pods	Columbia, S. C.	June 1931	83
Cracca virginiana	715	aerial	Old Fort, N. C.	June 1931	216
Cracca virginiana	749	seed pods	Alexandria, Va.	Aug. 1931	2 dead; 2 in distress
Croton tiglium	830	fruit	China	Dec. 1931	22
Dioscorea hispida	827	tubercles	Manila, P. I.	Dec. 1931	—†
Diospyros maritima	825	bark	Manila, P. I.	Dec. 1931	67†
Eremocarpus setigerus	789	aerial	Medford, Ore	Aug. 1931	33
Eremocarpus setigerus	795	aerial	Pacific Coast	Sept. 1931	55
Euphorbia corollata	717	whole plant	Western N. C.	June 1931	—
Jacquinia keyensis	930	leaves and stems	Great Inagua, Bahama Islands	Apr. 1932	—

"Limoncillo"	842	dried fruit	San Salvador	Jan. 1932	1 dead; 2 in distress†	
Lonchocarpus sepium	692	seeds	Porto Rico	May 1931		—
Lonchocarpus velutinus	785	roots	Lima, Peru	Aug. 1931		148
Lupinus diffusus	725	whole plant and seeds	Columbia, S. C.	June 1931		—
Lycium halimifolium	718	whole plant	Western N. C.	June 1931	slight distress	
Maesa denticulata	824	bark	Manila, P. I.	Dec. 1931		167†
"Mata gusano"	787	———	Lima, Peru	July 1931		127
Polygonum punctatum	846	aerial	Colombia, So. Amer.	Jan. 1932	2 dead; 1 in distress†	
"Sinihuite"	844	rhizomes	San Salvador	Jan. 1932		57†
Symplocos tinctoria	716	roots	Old Fort, N. C.	June 1931		70
Symplocos tinctoria	713	stems	Western N. C.	June 1931		—
"Yerba Santa"	786	———	Lima, Peru	July 1931	slight distress	
"Yerba Vitzca"	788	———	Lima, Peru	July 1931	serious distress	
Derris sp‡	612	roots	———	Jan. 1931		92

*The concentration used was 1 ml. of extract from 0.2 g. of plant material, per liter of tank water.

†Three fish were used per test instead of four.

‡Known to contain 1.7 per cent rotenone.

§A dash indicates that the fish were unaffected after 7 hours' exposure. In cases where death did not occur in a shorter period, the condition of the fish is described at the end of the 7-hour period.

was tested in a similar manner, and is included for the purpose of comparison.

TABLE 2. PLANTS MOST TOXIC TO GOLDFISH

Plant	I. D. No.	Survival time in minutes
"Bejuco chilio"	843	90
Cracca virginiana	723	83
Croton tiglium	830	22
Diospyros maritima	825	67
Eremocarpus setigerus	789	33
Eremocarpus setigerus	795	55
"Sinihuite"	844	57
Symplocos tinctoria	716	70
Derris sp	612	92

Preliminary toxicity tests have been made on various types of insects with those acetone extracts that killed goldfish in an average of one hundred and fifty minutes or less. The results indicate that a few of them possess considerable insecticidal value, and it is hoped to present the results of more complete tests of this nature in a paper of later date.[3]

NEW QUARTERS FOR WORK IN ENTOMOLOGY IN THE UNIVERSITY OF CALIFORNIA AT RIVERSIDE AND LOS ANGELES

By H. J. QUAYLE, *Riverside, Calif.*

In connection with the Southern Branch of the College of Agriculture of the University of California there has just been completed a new entomology building on the Riverside campus, and new quarters for the teaching of entomology on the campus of the University of California at Los Angeles. These facilities, in addition to the insectary at Riverside which was completed last year, constitute an unusually well equipped plant for entomological work.

The building at Riverside was built out of a legislative appropriation of $150,000.00. It is "L" shaped, two stories high and basement, with an attic greenhouse. The main part is 45 x 100 ft., and the projecting wing is 42 x 45 ft. It is a Class-A structure, of reinforced concrete and tiled roof.

In the basement is a spray application laboratory with a garage entrance for spray rigs and trucks, a fumigation tent room, machinery and refrigeration rooms, carpenters and mechanics shops, storage rooms,

[3]Thanks are due Mr. W. M. Davidson of the Food and Drug Administration, U. S. Department of Agriculture, for the insecticidal tests upon which these statements are based.

and a large room containing the air-conditioning equipment. This equipment consists of six independent cabinets, each with a working space of 2 x 4 x 4 ft., in which the temperature may be controlled to 1° within a range of from 30° to 120° F., and any humidity within the limits possible at the different temperatures. One cabinet is also equipped with thermo-time-control, which permits of different ranges of fluctuating temperatures automatically controlled within a 24-hour period. The light may be regulated in each cabinet from darkness to 1000-watts The air in the room surrounding these cabinets is oil-filtered and may also be conditioned within certain limits with regard to temperature and moisture.

On the main floor, besides the usual offices and laboratories, photographic room and dark room, is a spray laboratory, a general insecticide laboratory, an insect physiology laboratory, and a fumigation laboratory. In the fumigation laboratory is a duplex, 100 cu. ft. vacuum fumigator installation, and two fumigating rooms The two vacuum fumigators and one of the fumigating rooms are heavily insulated with cork, and in these any temperature may be obtained between 30° and 120° F., and the full range of humidity. The fumigators are equipped with special apparatus for charging with cyanide, carbon bisulfide, formaldehyde, carbon dioxide, ethylene oxide, and other fumigants

The second floor consists of a series of offices and laboratories combined; a taxonomic laboratory with 600 cases, of the museum type, for pinned specimens, and other cabinets for preserved specimens and microscope slides; a graduate student and seminar room; a dark room; and a roof deck 40 x 45 ft.

The attic greenhouse is 8 x 50 ft., with potting space at either end. An electric elevator enables plants to be transported from this greenhouse to the fumigating and air-conditioning rooms, as well as for transport of supplies to all floors.

An innovation in this building is in the type of window. The lower section is fixed and without screen, each half of the double window consisting of a single piece of plate glass without mullion This permits uninterrupted light for microscopic and other work at the tables along the windows. The walls and ceilings as well as the fixed furniture are of a light green finish, which is a more restful color, particularly in the strong sunlight of southern California, than is the usual cream or buff color.

The new entomology building is in close proximity to the insectary which was completed last year. The insectary is unique in that it consists of twenty insect-proof rooms where foreign insects as well as

others may be studied without danger of their escaping and becoming established. This building is also constructed of reinforced concrete with tiled roof. The size over all is approximately 50 x 100 ft.

The floor plan is shaped like the letter "H", with four practically identical wings connected by a main corridor, below which is a basement that is used as a machinery room. There is also a basement under one of the wings. The rooms are fitted with double steel sash with air space between, set in concrete so that the windows are non-openable. The glass is polished heavy wire plate, to prevent breakage and to admit the maximum amount of sunlight. Entrance to each corridor is through a heavy insect-proof door of special design, and from the corridor the insect rooms are entered through similar doors. The corridor is painted black and the corridor light is automatically extinguished when any insect room door is opened, in order to avoid attraction of the insects toward the doors.

There is forced ventilation providing a change of air every five minutes. The air enters the rooms through ducts screened with silk bolting cloth and is exhausted through similar screens. The air supply first passes through an air washer which accomplishes the three-fold purpose of removing dust, supplying humidity, and reducing the temperature during hot weather. When outside temperatures require it, the air supply passes over gas furnaces automatically controlled so as to develop a room temperature of about 70° F. Each room is also equipped with an electric heating unit and thermostat which permits a range of from 70° to 95° F. The supply and exhaust ducts of each room are equipped with air-tight dampers so that any room may be closed off and fumigated through a pipe connection in the door A large gas-fired incinerator is build in the main corridor where foreign plant cuttings, shipping boxes, etc , which have been used to import beneficial insects, may be burned after fumigation.

Quarters of the Division of Subtropical Horticulture in the University of California at Los Angeles have just been completed at a cost of $150,000 In these quarters three rooms have been set aside for the teaching of undergraduate entomology: one laboratory 22 x 45 ft., an entomological research laboratory 19 x 25 ft., and an office 10 x 19 ft. Instruction in entomology will be given during the second semester of the present year, when a course in elementary entomology will be offered. The following year an advanced course in citrus and other subtropical fruit insects will be offered, and thereafter both courses will be given during the second semester. The graduate work in subtropical fruit insects and in biological control will be given at Riverside as heretofore.

Above—Portion of new entomology building at the University of California Citrus Experiment Station, Riverside, California, on the left, and the new insectary at the right.
Below—West facade of the new entomology building at the University of California Citrus Experiment Station, Riverside, California.

Above: View showing four of the six air conditioning cabinets in the new entomology building at the University of California, Riverside, California. The refrigeration machine room (not shown) is in the immediate foreground and the refrigerant is conducted to the cabinets in the trenches shown in the floor. Below: View showing vacuum fumigation installation on the left and the doors of the two fumigating rooms on the right.

On account of the wide range of subjects in economic entomology requiring attention in California, and the widely separated groups of workers such as at Berkeley, Davis, and Riverside, a meeting of these groups was held during the past year and an organization and division of the work in the state was agreed upon, which as a matter of fact has been in effect since 1914. In administration W. B. Herms, head of the Division of Entomology and Parasitology at Berkeley and Davis, is in charge of the work in agricultural entomology in northern and central California, and is responsible for the work in medical and veterinary entomology throughout the state; H. J. Quayle, head of the Division of Entomology at Riverside and Los Angeles, has general charge of the work in agricultural entomology in southern California, and in so far as the work pertains to citrus over the whole of the state; and H. S. Smith, head of the Division of Beneficial Insect Investigations, has general charge of this work for the entire state.

It is not necessary here to go into detail with reference to further division of the entomological work in northern California. In southern California the research work on subtropical fruit insects is in charge of H. J. Quayle; that of beneficial insect investigations in charge of H. S. Smith; spraying investigations is in charge of R. H. Smith; walnut, deciduous fruit and certain subtropical fruit insects in charge of A. M. Boyce, who will also be in charge of the teaching work at the University of California at Los Angeles; and P H. Timberlake is in chage of the collection and taxonomic work.

Scientific Notes

Propylene Dichloride as a Fumigating Material. Some years ago in the United States Department of Agriculture Bulletin 1313, experiments with various organic materials were detailed Among the more efficient ones was propylene dichloride, which at that time was not available because of the high cost. Within the last few years this material has become available and the price very comparable with that of carbon disulphide. Laboratory and field tests with this material against various grain-infesting insects shows that mixtures of this material can be considered as efficient as carbon disulphide for fumigation against grain-infesting insects, without the fire hazard attending the use of the former material.

RAY HUTSON, *Department of Entomology, Michigan State College*

The Gladiolus Thrips, *Taeniothrips Gladioli* M. and S., in California. This thrips, which has recently become a pest of gladioli in many eastern and middle western states (and Canada), has been collected in southern and central California. It was first collected in California on April 30, 1932, by Mr. S. N. LaFollette, county agricultural Inspector, and Dr. Weigel of the Federal Bureau of Entomology, on the property of W. A Ritto, La Habra Heights (Los Angeles County).

Since the first record of the taking of this thrips in California, it has been collected in about fifty localities in Los Angeles County and in the southern counties of Ventura, San Diego, and Orange. The author collected *T. gladioli* at Davis (Yolo County) on July 16, 1932. All the collections were made from gladioli. Many of the infestations in the south were rather severe. The infestation at Davis was very light and an inspection of the corms has revealed no thrips on them since harvest.

T. gladioli has not as yet been followed through the winter in California but can no doubt readily survive in the field on other hosts.

STANLEY F. BAILEY, *University of California, Davis, California*

Arsenic in Bait-Poisoned Grasshoppers. Frequently the question is raised as to how much arsenic bait-poisoned grasshoppers contain. Following the spreading of some arsenical bait, prepared according to the Standard Government Formula, containing 5 pounds of arsenious oxide per 100 pounds of bran, a number of grasshoppers were collected for analysis. They were sorted approximately according to the three sizes shown in the illustration and analyzed for arsenious oxide according to the official Gutzeit procedure of the A. O. A. C. The results, also shown in the illustration, may be considered as average as the duplicate samples analyzed contained from 100 to 200 grasshoppers each. More arsenious oxide per grasshoppers was found than anticipated, and more than should be necessary to kill. This no doubt must be due to their large feeding capacity. According to the results, it would require 410, 304, and 259 grasshoppers of sizes A, B, and C respectively to yield one grain of arsenious oxide. The quantity of the poison found is somewhat proportional to their size and feeding capacity. The results indicate that the standard bait is quite attractive and palatable to the grasshoppers and that it is an economy to poison grasshoppers while they are young and small.

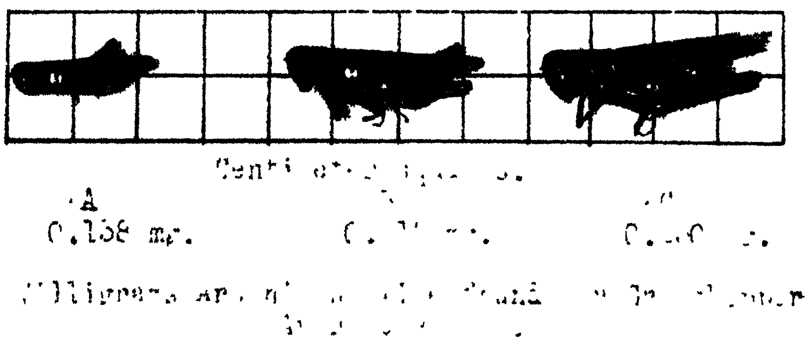

FIG. 25.--Grasshopper bait-poisoning results

T. H. HOPPER, *Agricultural Chemist, North Dakota Agricultural College*

Parasites from a Bird's Nest. It is of interest to note the varied collection of insects taken from the vacated nest of a pair of purple martins (***Progne subis***), immediately following the past nesting season.

The flea *Ceratophyllus idius* Jordan and Rothschild, which a few years ago had been collected from a similar situation, was particularly numerous. Well over one hundred specimens were found in the nest, together with a few larvae. This flea was originally taken from the tree swallow (*Iridoprocne bicolor*) in British Columbia, a bird having somewhat similar nesting habits to those of the purple martin, and which is a common summer resident in this part of Canada.

The next most numerous insect inhabitant of the nest was a calliphorid fly, *Protocalliphora splendida* MacQ. One hundred and twenty-one pupae of this fly were taken, from which a few adults were reared; 92.74 per cent of the pupae were parasitized by a chalcid, determined as being *Mormoniella vitripennis* (Walk.).

In addition to the three foregoing species, one *Dermestes lardarius* Linn adult and several larvae, and three psocids, *Troctes divinitoria* Linn., were also taken from the nest.

C. idius was determined by Dr. Carroll Fox, *P. splendida* by Mr. C. H. Curran, *M. vitripennis* by Dr. C. F. W. Meusebeck and *T. divinitoria* by Dr. A. N. Caudell.

W. E WHITEHEAD, *Macdonald College, P. Q.*

Abia americana (Cresson) on *Lonicera*. While this is a well known species of sawfly, there does not seem to be any easily available record of its host plants or life history. On April 12, 1930, my attention was called to a heavy infestation of sawfly larvae on a cultivated climbing honeysuckle (probably *Lonicera japonica*) in a Sacramento yard. No adults were obtained from these larvae as they had all been poisoned. On April 20, 1932, I again had an opportunity to collect larvae of this sawfly, this time on a hedge *Lonicera* of the *nitida* type, also in Sacramento After feeding this second lot for about ten days, they formed the characteristic brownish sawfly cocoons on the sides of the bottle or the surface of the soil. As no adults had emerged by June 20, one bottle was placed in a refrigerator at about 40-45 degrees F. On November 9, this bottle was removed from the low temperature and adults emerged about November 20, 1932. This would seem to indicate that the species is single brooded and that the larvae require low winter temperatures to prepare them for pupating. I am indebted to Mr. H. H. Ross, Urbana, Illinois, for the determination. For further information on this insect, see Howard's Insect Book, The Hymenoptera of Connecticut, and Insects of Western North America (Essig).

H. H KEIFER, *California State Department of Agriculture, Sacramento, California*

Rhizopertha dominicana as a Library Pest. For several years the books of the library of the School of Tropical Medicine have been infested by a small beetle. Specimens sent to Mr. A. Mutchler of the American Museum of Natural History were identified as *Rhizopertha dominicana* (Bostrichidae). This cosmopolitan form is known as a museum pest according to Miss I. Hawes of the Bureau of Entomology, who kindly consulted the literature pertaining to this species. No record of injury to books was found. Usually the beetles confine their activity to the inner portion of the back, though occasionally small discrete holes not unlike those of isolated termite borings in books could also be noted in the boards. A considerable amount of frass on the shelf beneath the volumes that had not been moved for some time served to indicate the presence of the insect. The binding becomes loose and less durable as a result of invasion.

Approximately a year and a half ago fumigation was resorted to. The library room and a small connecting annex have a volume of 10,320 cu. ft. Five pounds of Cyanogas A dust were spread over newspaper placed on the floor, and sprinkled with water. Doors and windows had been sealed with adhesive paper. After an exposure of 36 hours numerous dead larvae and adults were encountered on the shelves and shaken from the volumes themselves. A few living adults were also found in books. Within a few months they appeared to be as abundant as before.

One year later the operation was repeated in a similar manner except that ten pounds of the fumigant were used. At present, six months after the second fumigation there is no evidence to indicate the presence of this species. To prevent reinfestation by means of volumes not in the library at the time of fumigation, an air tight case suitable for fumigation has been prepared.

W. A. HOFFMAN, *School of Tropical Medicine, San Juan, P. R.*

A Braconid Parasite of a Coccinellid New to Puerto Rico. In March 1931 the writer investigated, in company with Mr. Fernando Chardon of the Insular Experiment Station, reports of a severe outbreak of the yellow cane aphis, *Sipha flava* Forbes, at the East end of the Island. A large field of young plant cane at a Central near Aguadilla was especially badly infested. The common Coccinellid beetle, *Cycloneda sanguinea* L., was exceedingly numerous thruout this planting and it was at first wondered how the outbreak of aphis could have progressed to such an extent in the face of such numbers of its predators. Pupae of the ladybeetle were unusually numerous on the cane leaves but upon examination at least 90% of them proved to be dead, with a neat round hole about the diameter of the lead in a pencil in the body wall of each. Larvae or pupae were found within many of the beetle pupae from which the parasites had not yet emerged. Unfortunately nothing but several small vials of alcohol were available for the preservation of the material so that no adult parasites were reared. A few of the Coccinellid pupae were placed in alcohol however.

Recently several of the parasite pupae and two of the adults which had emerged in the alcohol were sent to Dr. Morrison of the U. S. Bureau of Entomology for determination. Thru his kindness Mr. C. F. W Muesebeck has been good enough to report that the two adults and one of the pupae are *Homotylus terminalis* Say and that the two remaining pupae evidently represent a Pteromalid. This is apparently the first record of *H. terminalis* from Puerto Rico. *H. obscurus* Howard however was recorded by T. H. Jones as parasitic on *Cycloneda sanguinea* L. and *Megilla innotata* Mulsant at Rio Piedras in 1912 (See Wolcott's "Insectae Portoricensis" Jour. Dept. Agr. P. R. 7 (1): 66, 1923—published 1924).

M. D. LEONARD, *formerly Entomologist, Insular Experiment Station, Rio Piedras, P. R.*

Control of an Infestation of the Cigarette Beetle in a Library by the Use of Heat. Cases frequently arise in which it is not desirable to fumigate a room with poisonous gases in order to eradicate insect pests. The writer was recently asked to advise as to control measures to be taken for an infestation of the cigarette beetle (*Lasioderma serricorne* Fab.) in the library of the U. S. Circuit Court of Appeals in the post office building, New Orleans, La. The building was situated in a congested business section and was continuously occupied so that the use of hydrocyanic acid gas would have been attended with some danger. Accordingly it was decided to try to eradicate the

beetles by the use of heat. A gas burner with a capacity of 2½ cubic feet per minute was installed and a temperature of 140–145° F. maintained for six hours. Electric fans were used to secure an even distribution of heat in the room which measured 100 by 21 by 15 feet. The mean outside temperature for the day of treatment was 86° F., minimum 78°F., maximum 94°F. The books were loosened sufficiently to permit the hot air to circulate between the volumes.

Previous to the treatment the beetles were working in the leather bindings of books in all parts of the library, many volumes having been so badly injured as to need rebinding. Three days after treatment, an examination of books from different parts of the library showed many dead larvae, pupae and adults. No live insects could be found. Another inspection made 37 days later also showed no living insects. Since the longest incubation period reported by Runner[1] is 14 days, the absence of any living larvae in the second inspection showed that the eggs also had been killed.

The bookshelves were of steel, but wooden desks and tables were not removed from the room. They were not harmed by the high temperature The books were bound in sheepskin, and buckram and withstood the heat without injury.

A. W. CRESSMAN, *Associate Entomologist, U. S. Bureau of Entomology, Fruit and Shade Tree Insects Division, New Orleans, La.*

The Flannel Moth in Arizona. The middle of October this year my attention was called to a very unusual prevalence of flannel moth larvae in private grounds near Douglas, Arizona. The insects had inflicted most painful and serious injuries upon a number of persons and had caused the owner of the grounds to resolve to remove his shade trees in order to get rid of the pests.

Upon visiting the grounds I found that the larvae were present in enormous numbers, devouring the foliage of mulberry, apricot, pomegranate, apple and perhaps other trees, though shunning peach foliage. They were forming cocoons in solid masses under the eaves of the stone buildings, on stone walls, in "window corners," under boards on the ground and elsewhere.

As no definite method of control had apparently been worked out for these insects, I began to devise methods of procedure, suggesting that the cocoons be removed from the surfaces to which they were attached and destroyed, that more favorable sites for pupation be provided, such as throwing down additional boards on the ground around trees, and setting up shelf boards on the sides of walls. Apparently attempts had been made to poison the worms by the use of lead arsenate spray, and it was said that the larvae either did not eat the sprayed foliage or were not affected by it.

A workman had thrown an old pair of trousers through a crotch of a tree some two weeks earlier and it was found that about 100 cocoons had been made in and around this garment, which suggested that the trees might be loosely wrapped with sacks or old clothing as a means of collecting large numbers of cocoons.

Instances have been previously reported to me of injury resulting from the poisons of flannel moth larvae in this vicinity. A few trees in the city of Douglas have been found infested sufficiently to do some damage to the trees. Cocoons and larvae sent to the Bureau at Washington were identified by Mr. Heinrich as *Megalopyge bissesa* Dyar (?). Two other species of the Megalopygidae are extremely common in the Sulphur Springs Valley of this County. One of them, belonging to the genus Norape, completely defoliates the mesquite over many acres of ground each autumn. The

[1]Runner, G. A. The Tobacco Beetle, an Important Pest in Tobacco Products. U. S. D. A. Bull. 737, 1919.

other occasionally denudes hackberry trees. The latter two have not been known to inflict injuries on persons handling them. I have gathered a large number of specimens without being in any way affected. It is true also that one could quite easily handle the larvae of the species of Megalopyge above described so long as the insects did not come in contact with the unworn surface of the hand.

WYATT W. JONES, *Douglas, Arizona*

Coleoptera Captured in Japanese Beetle Traps.[1] Many species of insects are captured in Japanese beetle traps either because of the attraction of geraniol and eugenol in the bait or because the traps themselves, through their mechanical construction or color, are attractive. Because of the tremendous numbers of the Japanese beetles present in the trap containers it is usually impracticable, in an area heavily infested by that insect, to ascertain what species are thus captured. During 1932, however, nearly 400 traps were located in a pasture near Woodstown, N. J., and were baited before the Japanese beetle had emerged to any appreciable extent. This pasture was surrounded by a field planted to asparagus on the north, one in corn on the east and south, and by a pasture and potato field on the west. At this time (June 25–30) it was possible to collect from the traps many species which had never been taken previously. Even later in the season, when the Japanese beetle catch was heavy, a few species were found in such numbers as to be noticeable in large quantities of this insect.

The following is a list of Coleoptera taken from the traps. In many cases the number was so large that an accurate count could not be made in the time available and an estimate is made on the basis of one day's collections. It will be noted that the list includes several species of economic importance which were taken in considerable numbers. Species of other orders are not given because the collection and identification of these individuals constituted a task requiring considerable more time than was available.

Scarabaeidae	Number of individuals
Pinotus carolinus (L.)	25
Onthophagus hecate Panz.	30
Onthophagus pennsylvanicus Harold	12
Onthophagus nuchicornis (L.)	16
Aphodius fossor (L.)	10
Aphodius haemorrhoidalis (L)	25
Aphodius fimetarius (L.)	45
Ataenius cognatus (Lec.)	11
Serica sp.	5
Trox insularis Chev. (trap near dead chicken)	11
Diplotaxis sordida (Say)	1
Phyllophaga ephilida (Say)	200
Phyllophaga futilis Lec.	125
Phyllophaga fervida (Fab.)	15
Phyllophaga hirticula (Knoch)	120
Macrodactylus subspinosus (Fab.)	500
Pachystethus lucicola (Fab.)	13
Pelidnota punctata (L.)	5
Ochrosidia villosa (Burm.)	90
Dyscinetus trachypygus (Burm.)	250
Ligyrus gibbosus (DeG.)	175
Cotinis nitida (L.)	300
Euphoria fulgida (Fab.)	1
Euphoria herbacea (Oliv.)	14

[1]Contribution No. 109 from the Japanese Beetle Laboratory, Moorestown, N. J.

Of other families:

Carabidae	
Lebia grandis Hentz	300
Harpalus pennsylvanicus DeG	150–200
Harpalus faunus Say	150–200
Hydrophilidae	
Sphaeridium scarabaeoides (L.)	750
Sphaeridium bipustulatum Fab	63
Silphidae	
Silpha americana L.	11
Cantharidae	
Chauliognathus marginatus Fab.	500
Elateridae	
Alaus oculatus (L.)	3
Melanotus sp	400
Chrysomelidae	
Chrysochus auratus (Fab.)	25
Leptinotarsa decemlineata (Say)	200
Diabrotica duodecimpunctata (Fab.)	23
Diabrotica vittata (Fab.)	41
Curculionidae	
Hypera punctata (Fab.)	18
Other weevils	250

F. W. METZGER and R. J. SIM, *U. S. Bureau of Entomology, Moorestown, N. J.*

A Note on the Hibernation Habits of some Engraver Beetles of the Genus Ips. While it is the general habit of bark beetles to hibernate under the bark of the trees that have served as their larval hosts, such a habit is not universal. For many years it has been known that species of *Phthorophloeus* (*P. liminaris* Harr. and *P. frontalis* Zimm.) usually leave their larval host and bore into the bark of healthy trees of the same species and hibernate near the juncture of the dead and living bark. Several cases are on record in the files of the Division of Forest Insects of species of the genera *Ips*, *Pityogenes*, and *Pityophthorus* leaving their larval host in the fall, entering either dead, dying, or living trees, and hibernating under the bark in closely packed masses. Also in 1927 Watson published an account of the hibernating habits of the bark beetle, *Ips perturbatus* Eichh., showing that the adults leave their galleries in spruce in the fall of the year and descend into the ground to pass the winter. As far as known, this is the first published record of the habit for this genus in North America.

Recently, in studying the seasonal history of the western pine beetle (*Dendroctonus brevicomis* Lec.) infesting ponderosa pine (*Pinus ponderosa*) near Prineville, Oregon, wire cages were attached to the trunks of infested pines in such a way that emerging insects fell into and were caught in collecting jars. These cages, which enclosed about 2 square feet of bark surface, were put in place late in October without disturbing the natural conditions in the bark or the action of normal temperature or moisture.

It was thought that all activity had ceased for the winter, as the weather had turned cold and rainy with intervals of light snows. Despite these unfavorable weather conditions, we were surprised to find a rather heavy emergence of *Ips emarginatus* Lec. and *Ips oregoni* Eichh. during October and through November until after Thanksgiving. Apparently their habit is to leaye the bark in the fall of the year, drop straight down to the ground, and then seek shelter at the base of the trees.

The question as to what these emerging beetles were doing became of interest, and a search of the soil at the base of the trees was made. The engraver beetles were found

at the ground level and to a depth of 3 inches below, hibernating in the outer bark flakes and crevices The usual method was for an adult to select a fairly thick bark flake and bore a slightly curved tunnel into its interior to a depth of about half an inch In these short tunnels, each containing only one adult, the Ips beetles were found prepared to pass the winter A little search revealed large numbers of both species concealed in these improvised shelters

All of the adults do not necessarily descend to the ground to hibernate, for an inspection of the bark showed numerous adults hibernating in the old tunnels One of the characteristic habits of the bark beetles of this genus is for the hibernating new adults to congregate in large groups under the bark by chewing away the partitions between their pupal chambers This has been noted for *Ips confusus* Lec in single-leaf pinon (*Pinus monophylla*), for *Ips radiatae* Hopk in lodgepole pine (*P contorta*), and for *Ips vancouveri* Sw in western white pine (*P monticola*) This habit, like the ground hibernation habit just described, is probably characteristic of other members of the genus

Other secondary insects emerging in large numbers from the bark late in November and probably hibernating in the ground included adults of the staphylinid *Nudobius pugetanus* Csy (found abundantly in crevices of bark below ground) of the rhizophagid *Rhizophagus sculpturatus* Mann , of the colydiids *Lasconotus complex* Lec , *L subcostulatus* Kraus and *Aulonium longum* Lec and of the tenebrionid *Hypophloeus substriatus* Lec The most abundant larvae emerging at this time included a small undetermined dipteron (a cecidomyiid) and larvae of the clerid *Enoclerus lecontei* Wolc The latter build silk lined pupal cells under bark flakes at the ground line or below Some 20 other species of insects commonly found in the bark of trees killed by the western pine beetle were also collected in small numbers But the emergence of these did not indicate a general exodus for hibernation purposes

From a total of 16 cages not a single western pine beetle was collected even though all of the cages were over bark primarily infested by this beetle

F P KEEN, *Entomologist, U S Bureau of Entomology*

Notes on a Coccinellid (*Hyperaspis 8 notata* **Casey**) **Predacious on Citrocola Scale** (*Coccus pseudomagnoliarum* **Kuwana**) **in Tulare County, California.** The writer has for a number of years been interested in the subject of the biological control of our major insect pests The following notes deal with a Coccinellid predacious on Citricola scale, (*Coccus pseudomagnoliarum* Kuwana), in Tulare County

The larvae of this Coccinellid was first noticed by Mr Herman French of the Tulare County Agricultural Commissioner's office, in an abandoned orange grove near Terra Bella, in May 1929 (He brought some into the office for determination because of their superficial resemblance to mealy-bugs) Adult beetles reared from the specimens he collected and other larvae taken in the same grove were found to be *Hyperaspis 8 notata*, Casey

This specimen was described by Casey in 1899, from specimens from Arizona It is rather easily identified by its large size and its broadly rounded and strongly convex shape. It is larger than any of our California species of Hyperaspis, with the exception of *Hyperaspis lateralis* Muls The elytral ornamentation consists of a humeral marginal elongate spot, a rounded marginal spot behind the middle, a rounded subapical spot and a discal spot shaped like a broad crescent The larvae are covered with long white waxy filaments such as in some mealy-bugs, which they greatly resemble

This ladybird is presumably of rather recent introduction into this State. Until 1929 there were but four specimens in the Academy of Science collection in San Francisco, and all of these were from Arizona.

In 1928 the writer took this species in large numbers feeding on Monterey Pine Scale (*Physokermes insignicola* Craw) on Monterey Peninsula. I have also taken them in Sequoia National Park in very limited numbers, the host in this case being unknown.

Repeated collections were made in the orange grove near Terra Bella where this insect was first noticed. Their numbers increased during June, July and August in spite of the very hot weather. This being an abandoned grove, the Citricola scale was very plentiful. During the Fall, however, most of the trees died from lack of water, and the remainder were in such poor condition that they were entirely defoilated and died in the Spring of 1931, thus putting an end to observations in this plot.

In the Spring of 1931 another orange grove was found, near Porterville, in which there were a number of larvae of this beetle. By July the adult population was, in some cases, as high as 200 per tree. Part of this orchard was left unsprayed and it was hoped that some check on the value of this insect in controlling Citricola scale may be obtained, by next Spring.

With the exception of *Chilocorus bivulnerus* var. *orbus*, Casey, which was occasionally taken with the above species this is the only Coccinellid that I have observed or can find any record of feeding on Citricola scale, at least, in the San Joaquin Valley.

F. T. SCOTT, *Visalia, Calif.*

The Toxicity of the Common Castor-Bean Plant in[1] Respect to the Japanese Beetle. The common castor-bean plant (*Ricinus communis* L.) is not considered one of the favored food plants of the Japanese beetle (*Popillia japonica* Newm.) although occasional feeding on its foliage had been noted prior to 1932. During the winter of that year, articles appeared in two trade journals (Charles H. Landreth. "A New Way to Destroy the Japanese Beetle." Horticulture, Vol. X, No. 4, p. 74. Feb., 1932; Burnet Landreth, Jr. "Castor-oil Bean vs. Japanese Beetle." Florists Exchange & Horticultural Trade World, Vol. LXXIX, No. 18, p. 35. April, 1932) to the effect that a large-scale seed grower in the area heavily infested by the beetle reported this insect as being attracted to certain varieties of castor-bean foliage in considerable numbers. It was also stated that these beetles fed extensively and, as a result, were killed. The use of this plant as a killing agent for the beetle was widely advertised and it became evident that many would be planted because of their alleged value in this respect.

A series of tests was conducted during the summer of 1932 to determine the attractiveness and toxicity of the castor-bean plant in relation to the Japanese beetle. Twenty plants of each of six varieties, namely, Cambodgiensis, Panormitanus, Gibsoni, Red Spire, Sanguineus, and Zanzibariensis, were grown at Moorestown, N. J. Leaves of each variety were also used in cages under carefully controlled conditions, and many observations were made on numerous castor-bean plants growing in the area heavily infested by the Japanese beetle.

As a result of these observations and tests, it was evident that beetles fed on the varieties Sanguineus and Zanzibariensis but that the others were practically immune. This feeding was more pronounced after the seed pods had developed, but only in

[1]Contribution No. 110 from the Japanese Beetle Laboratory, Moorestown, N. J.

isolated cases was it of any appreciable extent, the most striking example being where castor-bean plants were located near a bed of Evening primrose (*Oenothera biennis* L.), an outstanding food plant of the beetle. Dead beetles were found under these plants in considerable numbers, but this mortality could not be attributed entirely to the castor-bean, as repeated observations have shown that dead beetles can always be found under plants which are heavily infested by this insect. Under certain field conditions, however, it appears that castor-bean foliage is toxic to the beetle.

In the cage tests, the beetle fed on castor-bean foliage to a limited extent, this being appreciable only on Zanzibariensis. In two tests, 20 per cent of the leaf area was eaten during a three-day period, with a resulting mortality of 17 per cent. In the check cages containing smartweed (*Polygonum pennsylvanicum* L.), a favorite food plant of the beetle, the plants were 75 per cent defoliated, with a mortality of 15 per cent. Cages with both castor-bean and smartweed showed 20 per cent feeding on the former and 75 per cent on the latter, the mortality being 10 per cent. These tests indicated that the castor-bean foliage was practically non-toxic. The data are somewhat contrary to those obtained under field conditions, where, as stated above, some beetles do appear to have died as a result of feeding on castor-bean leaves.

The tests proved conclusively, however, that no tested variety of castor-bean was sufficiently attractive to the beetle to induce the insect to leave favorite food plants in the immediate vicinity. The heaviest infestation on castor-bean plants was noted some time after the height of the beetle season at a period when favorite food plants had been severely injured. On the basis of present information, the castor-bean is of little or no value as a trap plant for the beetle under usual field conditions

A similar condition is found on certain species of geranium, *Pelargonium* spp (C. H. Ballou. Journ. Econ. Ent., Vol. 22, No. 2, pp. 289 293. 1929) and on silver-bell tree, *Halesia carolina* L. (H. Fox, unpublished, 1932).

F. W. METZGER, *U. S. Bureau of Entomology, Moorestown, New Jersey*

Outbreak of Grasshoppers in Tennessee During 1932. The past summer witnessed an unusually large increase in the abundance of grasshoppers in Tennessee. So far as the records show, this is the first year that these pests have been of economic importance. From time to time various species have been reported in injurious numbers in different sections of the State, but at the most they were only of minor importance. This year, however, the outbreak was general over the State. Maury County, in Middle Tennessee, suffered the greatest loss.

The most common species, the bird grasshopper (*Schistocerca americana* Drury), caused most of the losses, especially in corn and other field crops. The red-legged grasshopper (*Melanoplus femur-rubrum* De Geer) was less abundant and was usually found in pastures and alfalfa fields. Other species were also more abundant than usual, but of little importance compared to the two species mentioned above.

The unusual abundance of the grasshoppers clearly indicated that next year greater loss may occur unless the outbreak is retarded by parasites and unfavorable climatic conditions. It was therefore deemed advisable to perform experiments with poisoned bran mash to determine the best formula for use in Tennessee.

At Columbia, Maury County, on September 16, 1932, a single large experiment under field conditions was conducted with the red-legged grasshopper to determine the best formula for poison bran mash, and the temperatures most favorable for feeding. The formulas used contained, in addition to bran and water, sodium fluosilicate, amyl acetate, and molasses; sodium fluosilicate and molasses; and sodium fluosilicate

alone (with only bran and water). Paris green was used in similar combinations. On a basis of 100 pounds of bran, the materials were added as follows: Poison 4 pounds, molasses 2 gallons, amyl acetate 3 fluid ounces, and water 10 gallons. Analysis of the data by methods similar to those used by J. R. Parker (Minn. Agr. Exp. Sta. Bul. 214, p. 8) showed that the formula containing sodium fluosilicate, amyl acetate, and molasses ranked first. Sodium fluosilicate alone ranked second, and Paris green, amyl acetate and molasses ranked third. The remaining formulas were much less efficient. The data also showed that baits containing sodium fluosilicate attracted more grasshoppers than those containing Paris green.

The high toxicity of sodium fluosilicate has been well established (Marcovitch, Bul. 139, Tenn. Agr. Exp. Sta., 1928). Recently Richardson and Haas, working with *M. femur-rubrum* and *M. differentialis* (Jour. Econ. Ent. Vol. 25, 1932, pp. 1078–1088), showed that the M. L. Ds. for sodium arsenites, Paris green, and sodium fluosilicate are approximately the same. Of the poisons used by Richardson and Haas, they found no visible indication of olfactory or gustatory repellence. But when grasshoppers were allowed to feed *ad libitum* on poisoned bait, they found that on the average about twice as much of the baits containing sodium fluosilicate was consumed than of baits containing the sodium arsenites or Paris green.

From these experiments, sodium fluosilicate appears to be fully as effective in poison baits as Paris green. In addition, the sodium fluosilicate is much safer to handle and is less poisonous to man and livestock.

It was found that the addition of amyl acetate to baits containing molasses greatly added to their attractiveness.

Observations showed that for the optimum feeding period soil temperatures ranged from 80°F. to 109°F., air temperatures (not in shade) 12 inches above ground level, from 72°F., to 91°F., and air temperatures 30 inches above ground level, from 72°F., to 88°F.

A parasitic fly was fairly abundant. This fly was tentatively identified by J. M. Aldrich, U. S. N. M., as *Sarcophaga aculeata* Aldrich.

W. W. STANLEY, *Tennessee Agricultural Experiment Station, Knoxville, Tennessee*

Why Not Bourgault's Trap for Horse-Flies? Tabanidae have long been recognized as serious pests to live-stock. The injuries caused by these annoying flies are of a diverse nature, the more important of which are:

1. Loss of blood through the bites of the flies and a consequent reduction in the vitality of the animals attacked.
2. Disturbance of normal feeding and resting during the hours of the day when the flies are most active, which in some localities is said to be from 10 a. m. to 5 p. m.
3. Transmission and dissemination of diseases.

These and many others have made the study of Tabanidae, and a possible method of their control, of supreme economic importance, and in this country several investigations have been conducted by the Government and private institutions. Such were the motives for the studies made by Hine in Louisiana in 1903 and 1906, and supplemented in 1922 by Jones and Bradley. The U. S. Department of Agriculture undertook a study of Tabanidae in Antelope Valley (Nevada) in 1915, and the University of Arkansas in that state in 1927–28 with similar ends in view.

As a result of these investigations various remedies were proposed, such as the drainage and clearing of swamps and woods, the collecting of Tabanid egg-masses, the dissemination of egg parasites, and the application of kerosene to the surface of pools which the flies frequent.

But these remedies do not offer the cattle-grower any immediate, practical relief. Draining and clearing are long-term projects; collecting egg-masses is tedious and not convenient in all situations; while kerosene is not applicable to larger bodies of water.

Why not try the fly-trap devised by M. R. L. Bourgault du Cordroy for *Stomoxys* in Mauritius?

The trap is very simple and inexpensive, and the results are said to be excellent and rapid.

The entire trap consists of:

1. A darkened, partitioned building with entrance and exit doors.
2. A brush of leaves and branches.
3. A lighted chamber into which the flies are attracted after they are brushed off the animal, and where they are afterwards destroyed

Ten minutes are said to be sufficient for a herd of hundred oxen to enter the building, pass through the brushes, and come out the other end of the trap freed of the flies. After the first day, the cattle "go to the trap themselves and sometimes at a gallop."

Instead of taking the entire herd through the trap, one black, preferably tailless animal, is driven through the field, and when a number of flies have collected on its body, it is passed through the brushes.

The great value of the trap as a fly-catcher is testified by the Director of Agriculture of Mauritius, by the Government veterinary surgeon, and by estate managers and planters who saw the device in operation.

Stomoxys are terrific pests here also, at times, and the trap designed especially for these flies elsewhere would prove of real value in reducing their number in this country as well.

The trap can also be adapted for the destruction of Tabanidae on the ranches of our Western cattle-growing sections where they are a serious menace. The difference in the habits of Stomoxys and Tabanidae must be taken into consideration. While Stomoxys frequent barns and stables and at times enter dwellings, Tabanidae are primarily flies of the green field, the swamps, and the wooded area. They very seldom enter buildings, and may not react to the trap in the same way as Stomoxys does. But advantage may be taken of their feeding habits. According to the observations of Webb and Wells (1924) in Antelope Valley, a female completes her full meal of blood in about 10 minutes. During that time the fly is not easily disturbed, and does not withdraw until it feeds to satiety. If the animals can be trained to go through the trap automatically, as testified, the flies would be trapped and brushed off while feeding. A trap constructed conveniently in the pasture would be a real aid in relieving the cattle of these annoying flies.

A detailed description of the device and illustrations of the patented "Trap for Destruction of Cattle-flies," is given in the Journal of the Royal Army Medical Corps, Volume LIV, No. 3, pp. 208–211. London, March, 1930.

BERNARD SEGAL

Comparative Toxicities, with Special Reference to Arsenical and Fluorine-Containing Insecticides. With the increasing complexities of present day civilization mankind is being subjected to an ever expanding number of chemical elements and

their compounds. The possibility of acute poisoning and chronic intoxication by these new factors in man's environment is a subject of great importance to the public health. The causes of acute poisoning are more or less easily recognized and measures of treatment and prevention can be adopted relatively early. The insidious nature of chronic intoxications, and the consequent greater difficulty of relating symptoms to the causative agent, make this form of toxicity a subject of greater concern to the public health.

One of the many avenues through which we are being subjected to possible chronic intoxication is the widespread and increasing use of insecticides. The ideal and perhaps unattainable insecticide is a substance of high acute toxicity to a wide variety of insects and zero or negligible toxicity, both acute and chronic, to man. Because of the lack of such a substance, we are forced into the position of considering the comparative toxicity to man of various insecticides and of selecting the lesser evil.

It is important to review briefly the fundamental points which should be borne in mind when making such comparative studies. Regardless of whether we are concerned with acute poisoning or chronic intoxication, the difficulty of species differences is met with at the outset. Data must be obtained experimentally, on lower animals preferably, on a variety of species, and then tentatively transferred to man on the assumption that the threshold for the development of toxicity in man is no lower than the average threshold in other species.

The procedure for obtaining comparative data in acute toxicity is fairly simple. The substances whose toxicity is to be compared should be administered by the same route, subcutaneously, intramuscularly, intraperitoneally, intravenously, or by inhalation, and the same criteria for judging toxicity must be employed. Usually, a comparison is made of the dosages required to produce death in an arbitrary percentage of the animals, say 50 per cent. Under certain circumstances, it may be more desirable to make comparisons in terms of the effects on pulse rate, blood pressure, respiratory rate, temperature, or motor activity, as indicated by the degree of excitation or depression. Because of species differences, the toxicities of two substances must always be compared for the same species. Lastly, the substances should always be administered in the same form. For example, if the toxicity of a given metallic salt is being compared with the toxicity of bichloride of mercury, it is essential that the same solvent be employed. The toxicity of bichloride of mercury in distilled water is greater than when it is dissolved in sodium chloride solution, and much greater than when it is dissolved in potassium iodide solution. The formation of complex ions, particularly in potassium iodide solution, is responsible for a marked reduction in toxicity. Briefly, a uniformity of all conditions and criteria of judgment is essential for significant comparative data.

The comparison of the ability of two or more substances to produce chronic intoxications is more difficult and less satisfactory. We are not interested in knowing the daily dosage per unit of body weight which will eventually kill the average individual. Instead, we are interested in the daily dosages per unit of body weight which will produce an undesirable deviation from normal without killing an individual. Interference with growth or production of loss in body weight of an adult is often utilized as a basis for judging chronic intoxication. But this may reasonably be considered as an insufficiently delicate criterion. Before lack of growth or loss of body weight occurs, there may be other symptoms sufficient to condemn a substance completely, or to require a decrease in the daily intake, e. g., a loss of hair, change

in appearance of teeth, drying of skin, nervous manifestations, insomnia, etc. How are we to compare the ability of two substances to produce chronic intoxication when the undesirable symptom in one case is loss of hair, and in the other case an abnormal whitening of the teeth? Some individuals may prefer loss of hair and some whitening of the teeth. Obviously, that abnormality is least desirable which reflects the most deep-seated harmful disturbance of the organism. Perhaps the loss of hair is a manifestation of a disturbed cysteine metabolism, a disturbance of the role played by the sulphydryl groups in oxidation and reduction; perhaps the abnormal teeth reflect a disturbed calcium metabolism.

There is justification, therefore, in considering chronic intoxicants individually, each on the basis of its own peculiarities and the extent to which it may menace health. But, if comparisons must be made, then uniformity of experimental conditions must be adhered to. Comparisons must be made on the same species, with the same mode of administration, and with the experimental animals under uniform conditions of sanitation and quality of food. The toxic agents should be administered in the form and in the manner in which the living organism would come in contact with the material naturally.

At the present time it is desirable to find a good substitute for lead arsenate as an insecticide. Various fluorine-containing compounds, such as cryolite and barium fluosilicate, are being advocated. Comparative toxicity data have been published showing that the fluorine compounds are less toxic than lead arsenate. Marcovitch[1] has recently stated that a comparison of the amounts of arsenic and fluorine compounds necessary to retard growth of rats shows the fluorine insecticides to be 100,000 times safer than arsenic insecticides, but that in view of the fluorine normally present in foods, the marginal safety factor in 75. Recent investigation has shown that a definite abnormality of teeth may be produced in experimental rats by concentrations of fluoride which do not retard growth. Smyth and Smyth[2] compared the relative toxicity of fluorine and arsenical insecticides by means of feeding experiments conducted on white rats over a period of sixteen weeks. They made use of the tooth abnormality caused by fluorine as one index of toxicity. They concluded that arsenical compounds, such as lead arsenate, are several times more toxic than fluorine insecticides, such as cryolite and barium fluosilicate. This conclusion, based upon well-planned and controlled experiments, is more conservative with regard to the harmlessness of fluorine.

In view of the wide variation in different species in susceptibility to toxicity of a given agent, and in view of the extremely low concentration of fluorine in the drinking water at St. David, Arizona, an endemic area for mottled teeth,[3] it would not be surprising to find eventually that in man the margin of safety for fluorine insecticides is no greater than for arsenical materials.

Until the lowest possible threshold tolerance for fluorine compounds has been established in several species, and until the fullest use has been made of information to be gleaned from areas where mottling of teeth is endemic, the question of the wisdom of substituting fluorine-containing insecticides for lead arsenate must remain an open one.

FLOYD DEEDS, *Senior Toxicologist, Bureau of Chemistry and Soils,*
U. S. Department of Agriculture

[1]Marcovitch, S.—Journal of Economic Entomology, 1932, Vol. 25, page 141.
[2]Smyth, H. F. and Smyth, H. F., Jr.—Journal of Industrial and Engineering Chemistry, 1932, Vol. 24, page 299.
[3]Smith, M. C., E. M. Lantz and H. V. Smith, Arizona Agr. Exp. Station Technical Bulletin 32, (1931).

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

FEBRUARY, 1933

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A. A. A. S. Winter meetings 1933-34 Boston, 1934-35 Pittsburgh, Summer meetings 1933 Chicago, 1934 San Francisco

The Atlantic City meeting was held under most favorable conditions, and the thanks of the Organization are due to the local committee. The Editor wishes to call attention in particular to the brief discussion of Association policies and activities at the close of the final session. It is difficult to secure adequate time for the consideration of business details, and yet these have an important influence upon the Organization and its activities. The general policy of the Association, while it is determined in large measure by the Executive Committee and the officers of the various sections, represents in the final analysis, decisions which command the support of the majority. One of the serious difficulties in obtaining well considered decisions is due to a natural disinclination to make definite plans at one meeting for the next, and many of the decisions, and for that matter reports of some committees are not formulated until shortly before the meeting at which they are to be put in effect or presented. The experience of one meeting should be utilized in the modification, if advisable, of the procedure for the next and the time to start consideration is early in the year.

The editor is naturally much interested in the possibilities of comprehensive, really informative abstracts and is of the opinion that we might well follow the procedure of other organizations and publish these in the program. He has in mind a real summary of what the author proposes rather than a mere suggestion or bare outline which has heretofore characterized most of the summaries printed in the program. The

abstracts appearing in the Journal more nearly approach this ideal, though not all are entirely satisfactory. It should be possible to prepare these abstracts in time for inclusion in the program, and it has been suggested to the editor that these abstracts as printed might be made a part of the permanent record and simply cited when the paper itself is published rather than to reprint this matter Such an arrangement would result in a comprehensive summary of the paper, the early publication of the abstract with practically no additional expense, and it might even be possible to rule that a paper presented in this form should take its place on the program as having been presented, since the five minute regulation now in effect practically compels the presentation of an abstract. In certain cases at least, an author might feel that the printed abstract was the equivalent of any informal summary and the time ordinarily employed in the presentation could be utilized to greater advantage in a discussion of the more salient points. This general proposal could be tested at the Boston meeting under conditions where time will presumably be at a premium. We need to take advantage of any method which will allow the maximum time for essentials.

Obituary

ALONZO WILLIAM LOPEZ

Alonzo William Lopez, Member of the American Association of Economic Entomologists, died following a pneumo-thorax treatment for tuberculosis, in Pottenger's Sanitarium, Monrovia, California November 2, 1932. He was born at Santa Ana, California, August 23, 1900, and graduated with the degree of B. S. at the University of California, in December, 1926. He majored in entomology and parasitology and in 1928 secured the M. S. degree.[1] During this latter period he acted as laboratory assistant to Prof. W. B. Herms, and as field assistant to Dr. R. H. Smith at Riverside. Following his graduate work he was technical assistant to Prof. Herms from January 1 to May 1, 1929, when he received the appointment as Entomologist in Charge, Research Bureau, Philippine Sugar Association, with headquarters at La Carlota Central, Philippine Islands. He sailed from San Francisco May 21 and arrived at Manila July 4, 1929. At La Carlota he had a well equipped entomological laboratory, an entomological assistant, and two laboratory

[1]His thesis, Morphological studies of the head and mouthparts of the mature codling-moth larva, *Carpocapsa pomonella* (Linn.), appeared in U. C. Pub. Ent. vol. 5, No. 4, pp. 19–36, 16 Figs., 1929.

assistants. Being partly of Spanish origin and somewhat familiar with the language, he was able to accomplish much under conditions which would have been rather trying for many another entomologist. He was concerned with the enemies of the sugar and chiefly with the Buc-an or Labug-labug, *Leucopholis irrorata* Chevr., and the related white grubs, *Stephanopholis philippinensis* Brenske, *Lepidiota pruinosa* Burm., *Anomala nerissa* Ohs., and *Holotrichia* sp. The life histories were studied and much attention was given to the parasites, especially to the gold-collared digger wasp, *Campsomeris aureicollis* Lep., and also to *C. reticulata* Cam., *C. asiatica* Sauss., *C. luctuosus* Smith, *C. annulata* Fabr., *C. aurulenta* (Smith), *Scolia manilae* Ash., *S. scutellaris* Gribodo, and *Liacos analis* Fabr., all of which attack the grubs. Artificial control measures were also instituted including a beetling campaign whereby 16,331,415 adult beetles were collected largely from cane leaves at night by the aid of torches.

As a result of these investigations he published the following papers and reports:

A plan for the encouragement of the wasp parasites of the Buc-an. Sugar News, vol. 11, No. 4, pp. 197-198, April 1930.

The white leaf louse (*Oregma lanigera* Zehnt.) of cane and the introduction of a new wasp parasite of it. Ibid., vol. 11, No. 9, pp. 519-528, 6 Figs. 2 pls., Sept. 1930.

Do not destroy wasp cocoons. Ibid. (No paging or dates to separate received.) 1 Fig.

Ann. Rept. Ent., Research Bur., Philippine Sugar Assoc., 1929-1930, pp. 145-172, Figs. 27-31, pls. VI-X, 2 colored, 1930. Ibid., 1930-1931, pp. 227-273, tables 81-101, Figs. 46-49, pls. IV-VII, 2 colored, 1931.

The use of the antennae as a means of determining the sexes in *Leucopholis irrorata* adults (Coleoptera, Scarabaeidae). Philippine Jour. Sci., vol. 46, No. 4, pp. 759-761, pl. 1, 1931.

Early in the year 1932 he contracted tuberculosis and, when he could no longer remain in the Islands, returned to his home in Hollywood, California, on October 21, 1932, and was immediately removed to the sanitarium. He appeared to be in good spirits and fair physical condition up until the fatal treatment.

E. O. Essig

Review

Medical Entomology, A Survey of Insects and Allied Forms which Affect the Health of Man and Animals by WILLIAM A. RILEY and OSKAR A. JOHANNSEN, pages i-viii, 1–476, 183 text illustrations. McGraw-Hill Book Company, Inc., New York and London, 1932.

This new addition to entomology is a revised, re-written work based upon the earlier volume by these authors and published as a: "Handbook of Medical Entomology." The earlier work commended itself highly to entomologists and medical men alike, and the same will prove to be the case in this new volume, which contains and presents in an attractive form a vast amount of information regarding this vital phase of entomology. The authors have seen fit to present the text matter in a more systematic order than in the preceding work, and this appeals to the reviewer as a distinctly better arrangement. It is written, as in the case of the earlier volume, for both entomologists and medical men confronted by problems in connection with insect borne diseases and, in our judgment, both interests have been admirably served. The distribution of the various keys for the separation of groups, genera and species contributes greatly to helping the medical man who may not be a specialist in insect identification and detracts in no manner from the utility of these keys for the technical entomologist. The cosmopolitan character of this work is suggested in the keys for the separation of mosquito genera. There is one for the recognition of the genera of the world, another for the Palearctic species of Anopheles, another for the African species of Anopheles, another for Oriental and Australasian species of Anopheles and, finally, one for the recognition of North and South American species of this genus.

The scope of the work is practically the same as in the earlier volume. Special attention has been given to the history of medical entomology, and the well selected bibliography makes it possible to follow this out to almost any desirable extent. The various disease-carrying insects are considered in separate chapters, each with a key for the separation of the more important forms as well as a discussion of the more essential data. Those who have been confronted by the difficulties of identifying the immature stages of the Diptera will appreciate greatly the key for the recognition of myiasis producing dipterous larvae in their several stages. The extended, well selected bibliography adds greatly to the value of this work.

The authors and publishers are to be congratulated upon the production of such a generally useful, practical work. It is a real contribution to human welfare and a scientific production of no mean value.

E. P. FELT

Current Notes

Farmers in Canada have been advised of a destructive white grub outbreak which will develop in eastern Ontario in 1933.

Professor Herbert Osborn and Mrs. Osborn sailed for Bermuda soon after the close of the science meetings at Atlantic City in December. They expect to return early in April.

Dr. J. M. Swaine of Ottawa, Canada, gave the public address before the Entomological Society of America on the evening of December 28. The lecture was well illustrated and was highly instructive and entertaining.

On Oct. 14, Mr. J. C. F. Fryer, Chief Entomologist of the British Ministry of Agriculture, arrived in Montreal from England, in connection with the Colorado potato beetle embargo. Mr. Fryer spent a few days in Ottawa, and then proceeded to the Maritime Provinces with Mr. Gibson, where he examined the handling and inspecting of potatoes for export.

A unique feature of the Entomologists Banquet at the Atlantic City meetings was the relating of interesting incidents by American workers who have recently been in Foreign countries on Entomological duties. Prof. W. C. O'Kane was toastmaster, and called upon J. J. Davis, Max Kisliuk, W. S. Regan, T. R. Gardner, J. M. Swaine, E. F. Phillips, and F. C. Bishopp. Dr. Phillips' description of "A Russian Bath" was especially amusing.

Dr. M. D. Leonard has completed his work as Consulting Entomologist for a New York City exterminating company and has accepted the position of Research Entomologist for the John Powell & Co., Inc., of 114 East 32nd St., New York City. He will make his headquarters in Orlando, Florida and will have charge of an extensive program of field experiments with pyrethrum for the control of insects affecting vegetable and other crops in Florida.

Dr. R. H. Painter, Associate Professor of Entomology, Kansas State College, has received a grant of $300.00 from the Bache Fund of the National Academy of Sciences to be used for taxonomic studies of the Bombyliidae in the Museum of Comparative Zoology, Cambridge; American Museum of Natural History, New York; Academy of Natural Sciences, Philadelphia, and the United States National Museum, Washington, D. C. This is the third recognition which Doctor Painter has received recently for his taxonomic studies of the Bombyliidae. The others were an award of $125.00 from the Permanent Science Fund of the American Academy of Arts and Sciences, and a request from the Editor of the Lignan Science Journal to Classify the Bombyliidae of China, which monograph has been published. Doctor Painter left Manhattan December 4th for the studies in the eastern museums, and spent some six weeks at this work.

It will be of interest to all workers in Biology to learn that the Council of the Biological Society of Washington, at its last meeting, has voted the granting of a special price reduction on the following of its publications: "Natural History of the District of Columbia," by W. L. McAtee, 142 pages, inset map, octavo, paper. 1918. $1.00, postpaid $1.15; "The International Rules of Zoological Nomenclature," 28 pp. octavo, paper, 1926, 50c; "Birds of the Washington, D. C. Region," by May Thatcher Cooke. 79 pp. octavo, paper, 1929, 50c. These can be obtained, post paid,

from the Society's corresponding secretary, J. S. Wade, U. S. Bureau of Entomology, Washington, D. C., at the prices indicated. Requests should be sent promptly as only a very limited number of copies remain.

Horticultural Inspection Notes

Mr. B. M. Ault has been transferred from Nogales, Arizona to the port of Bellingham, Washington, effective January 1, 1933.

Mr. C. P. Daley of the Division of Foreign Plant Quarantines, was transferred from El Paso, Texas to Nogales, Arizona, January 1, 1933.

Mr. Geo. G. Becker visited Chicago, Detroit and Buffalo, January 4 to 6, and conferred with inspectors stationed at those ports on plant quarantine problems.

The Federal quarantine on account of the scale insects attacking date palms has been modified effective December 1, 1932, to remove the red date scale (*Phoenicococcus marlatti*) from consideration. The quarantine hereafter will apply solely to the Parlatoria scale (*Parlatoria blanchardi*).

The sweet potato weevil quarantine of Arizona was modified on September 15, 1932, releasing a part of the State of Louisiana from quarantine. The area in that State now designated as infested consists of that part south of and including the following counties: Calcasieu, Jefferson Davis, Acadia, St. Landry, Pointe Coupee, East Baton Rouge, Livingston, Tangipahoa, and Washington.

Recent seasonal changes in the transit inspection service have included the transfers of Mr. James T. Scott from Chicago to New York; Mr. C. B. Beamer from New York to Boston; Mr. H. J. Conkle from Boston to New York; Mr. James T. Moran from New York to Chicago, and Mr. Vincent F. Peterson from St. Paul to Kansas City.

The Federal quarantine on account of the Japanese beetle was revised effective January 1, bringing parts of the States of New Hampshire and Vermont under restriction, and modifying the boundaries of the regulated areas in Maryland, Massachusetts, New York, Pennsylvania, and Virginia. An amendment making minor additional changes in the boundaries in Maryland and Pennsylvania was later issued, effective January 23.

Mr. W. H. Wicks, Director, Bureau of Plant Industry, Boise, Idaho, reports that one new pest entered that State during the year, namely the European elm leaf beetle. The locust borer occurs in the City of Spokane, Washington, and the Idaho Locust Borer Quarantine issued in March, 1932, is designed to prevent its introduction from Washington, as well as from other sections where this pest occurs.

The Georgia State Board of Entomology, on January 12, 1933, modified its quarantine relating to the European corn borer to permit the entry of restricted articles provided each container is accompanied by an inspection certificate of the Federal Bureau of Plant Quarantine. Effective on January 1, 1933, the Board had placed a modification permitting the entry of rooted chrysanthemum cuttings under State or Federal certificate showing inspection within five days of certification.

Pine-shipping permits have been issued by the Federal Bureau of Plant Quarantine to six nurseries under the provisions of the recent revision of the regulations supplemental to the Federal white pine blister rust quarantine. Two of these nurseries are located in Iowa, one in Wisconsin, one in West Virginia, one in Idaho, and one consisted of a renewal of a permit to a New York concern. Applications from nurseries in a number of other States are still pending.

A public hearing was held at Memphis, Tenn., on December 13, 1932, before the Federal Bureau of Plant Quarantine to consider the advisability of extending the quarantine on account of the phony peach disease to the States of Missouri and Oklahoma. Those in attendance, in addition to the members ot the staff of the United States Department of Agriculture, included plant quarantine officers and nurserymen from the States of Alabama, Arkansas, Georgia, Illinois, Louisiana, Missouri, Oklahoma, Tennessee, and Texas.

Twenty-two States have issued quarantines relating to the European corn borer following the revocation of Federal Quarantine No. 43 on July 15, 1932. These States are: Arizona, California, Colorado, Florida, Georgia, Illinois, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Nebraska, Nevada, Oklahoma, Oregon, South Carolina, Tennessee, Texas, Utah, Wisconsin, and Wyoming. A summary of these quarantines has been compiled by the Bureau of Plant Quarantine and published as BPQ No. 346, dated December 10, 1932, and a supplement has since been issued.

The Secretary of the Eastern Plant Board reports that the Board has directed its efforts during the past year towards the simplification of procedures under which products move in commerce. To this end it is making certain recommendations with regard to bonds and fees and with regard to the minimum number of certificates that shall be attached to each package going interstate. Consideration has been given to the chaotic condition that exists as the result of the rescinding of the European Corn Borer Quarantine and recommendations with regard to the present situation and looking towards the prevention of similar future conditions. The present situation is probably the most serious that enforcement officials have ever had to face and it is felt by the Eastern Plant Board that unless prompt action is taken to remedy the conditions along fundamental lines, by close cooperation of all States and the Federal forces, reprisal actions are likely to follow that may and probably will result in a stifling of interstate trade, not alone in plant products, but in all phases of commerce.

On December 13, Federal Quarantine No. 58, governing the entry of fruits and vegetables from Puerto Rico was amended to provide for the admission of a considerable number of fruit and vegetable products in addition to the limited list previously authorized. The quarantine first became effective on July 1, 1925. Mr. Lee A. Strong, Chief of the Bureau of Plant Quarantine, states that during the intervening period since the original adoption of the regulations "there has been some opportunity to make more accurate estimate of the pest risk attending shipments of fruits and vegetables from the island; and because of the wider knowledge thus attained on the pest situation, coupled with considerable confidence in established methods of safeguarding such shipments by point-of-origin inspection and certification, it would appear that the somewhat restricted list of fruits and vegetables originally permitted entry to the mainland could be safely extended."

Medical Entomology Notes

Word has just been received of the letting of the contract for the erection of a new unit of the Rocky Mountain Spotted Fever Laboratory at Hamilton, Montana. The cost will be approximately $67,500. This, together with the present $60,000 plant erected by the State of Montana and recently taken over by the Public Health Service, will constitute one of the most complete and modernly equipped laboratories in the country devoted to a special purpose. It is only within the past decade that the activities, initiating some years previously with the problem of Rocky Mountain spotted fever, have been extended to include other tick-borne diseases. Opportunities are also accumulating for the study of additional parasitic conditions, particularly as related to arthropods. The necessity for enlargement of laboratory space has been due primarily to the rapidly increasing demand for the Spencer-Parker prophylactic vaccine for spotted fever, which is manufactured at present only at this institution. The combined floor space of the buildings, including basements but excluding outbuildings, will be 16,920 square feet, the dimensions of the present and new buildings being 40 x 66 and 50 x 60 feet, respectively. Two of the important features include a library, for which there is already a nucleus of important literature pertaining to public health entomology, and a museum with as complete a representation of ectoparasitic and host forms of the territory covered as it is feasible to get together. Materials are being accumulated as rapidly as possible with these ideas in view. The Entomologists on the Station staff are Dr. R. R. Parker, who is in charge of the Station, Dr Cornelius B. Philip, R. A. Cooley, Glenn M. Kohls and Wm. L. Jellison.

JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 26 APRIL, 1933 No. 2

Proceedings of the Fourth Annual Paper-Reading Session of the Eastern Branch of the American Association of Economic Entomologists

Friday Morning Session, December 30, 1932

THE EFFECT OF RADIO WAVES ON INTERNAL TEMPERATURES OF CERTAIN INSECTS[1]

By THOMAS J. HEADLEE, Ph.D., *Entomologist, New Jersey Agricultural Experiment Stations*

ABSTRACT

In the production of high temperature lethal effects on certain insects subjected to lines of force in an electrostatic field, it is a matter of prime importance that internal heat production shall be as rapid as possible. This speeding up of heat production can be accomplished through increasing the strength of the electrostatic field.

All studies of the effect of radio waves upon living organisms placed in the electrostatic field indicate that these effects are the result of heat developing and accumulating within the organism. Just how electric energy bathing the tissues is absorbed and transformed into heat appears to be a matter of theory. Christie and Loomis (3) say that heat is generated by conduction of high frequency currents induced in the organism under these conditions. Hosmer (9) thinks that the development of heat is due to the increased rate of molecular vibration within the cells and that this increased rate of vibration is chargeable to the alternate attraction of the molecules first to one electrode and then to the other. It may be, of course, that both explanations are merely different facets of the same jewel.

Still other investigators, such as Headlee and Burdette (8) and Head-

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

lee (6) have envisioned this heating as due to accelerated vibrational rate occasioned by the receipt of spurts of electrical energy at a rate more or less in tune with the normal rate of vibration of the bodies concerned. The latter writer (6) has gone as far as to indicate that less expenditure of electric energy will be required to produce the same heating effect when the vibrational rate is better tuned to the organism.

From the standpoint of the student of physics, Christie and Loomis' theory probably presents the clearest picture. From the point of view of the biologist Hosmer's conception is the most enlightening. Doubtless either could be used to explain the fact that certain regions of radio bands produce different effects as shown over a wide range of frequencies by Schereschewsky (14) and over a comparatively narrow range by Headlee (6). Indeed they might be invoked to explain the differential demonstrated between animal and plant organisms as shown by Headlee (6).

Nevertheless, the induced currents of Christie and Loomis and the alternate attraction of the molecules postulated by Hosmer, are undeniably influenced by the nature of the organism under test and who can say that this influence is not the result of the normal vibrational rate of atoms, molecules, and molecular aggregates composing the organism under test.

It seems to the writer that the conception of synchronization of the rate of delivery of electric energy with the normal vibrational rate of atom, molecule and molecular aggregate is much the most fundamental and may reveal itself in the nature of the induced currents of Christie and Loomis and in the molecular attraction of Hosmer.

At any rate, this conception of synchronization or resonance, as the basic proposition in heat effect, opens a boundless field for influencing living matter by the use of a small amount of electric energy administered on the principle of selectivity.

Regardless of the mechanisms involved in this phenomenon of heat production within the organisms, it seems perfectly clear that the living organism when in the electrostatic field absorbs electric energy and transforms much of it into heat energy.

To produce lethal effects heat accumulation within the living organisms must greatly overbalance heat radiation from its external surface. Insects, as a rule, are of small size and large surface in proportion to volume. Furthermore, many insects are very thin skinned. Heat accumulation must, therefore, be rapid. Living honey bees exposed in the electrostatic field with 3,000,000 cycles and a barely lethal field strength

will show some specimens that exhibit the phenomenon of high excitement as internal heat rises but as the exposure continues will continue active and living for more than one-half an hour. The high excitement period is short and thereafter they return to normal behavior. Evidently,

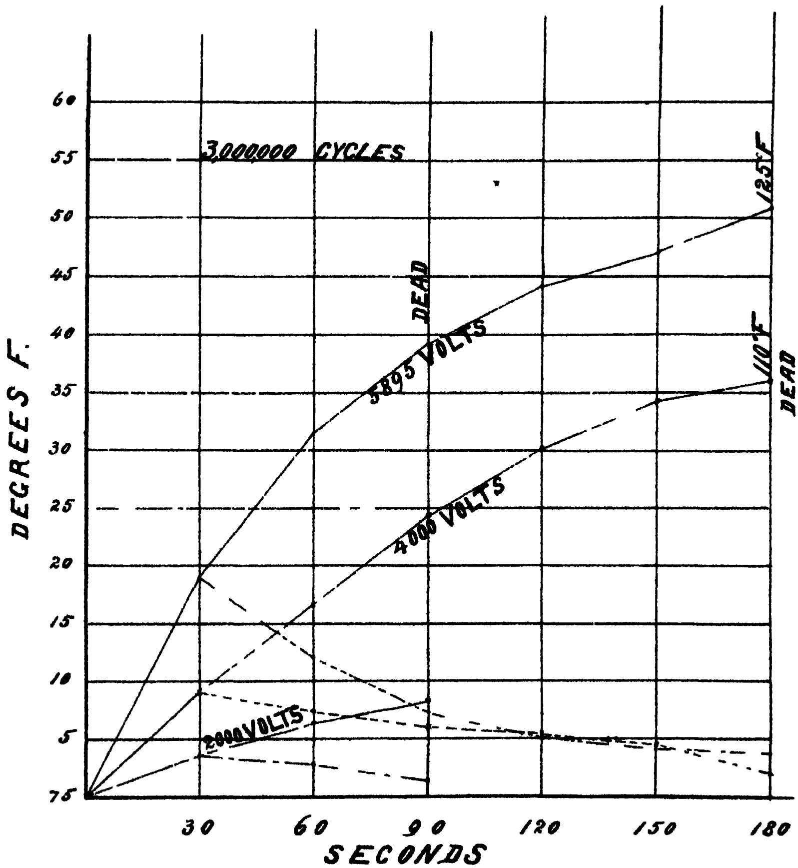

FIG. 26.—Degrees Rise in Temperature Plotted Against Time The solid lines represent the rise of internal heat of the insect tissues under treatment in the electrostatic field. The dotted lines represent the increment in heat.

preceding the change of behavior, heat radiation from their bodies has caught up with internal heat production. The same phenomenon has been found when working with grubs of the Japanese beetle.

It is a matter then of large importance to promote heat accumulation at the maximum rate. Realization of this fact lead to a study of the rate of heat accumulation in certain insects when exposed in the electrostatic field.

The third instar grub of the Japanese beetle has been used for this study because of its slowness of reaction, its thin skin promoting heat radiation and its availability.

At the beginning of a run the thermocouple was inserted in the grub's thorax while enclosed in a small glass tube. The tube was placed between the aluminum electrodes. The temperature was promptly determined. The vibrator was thrown into operation. At the end of each 30 second period the power was switched off, the galvanometer balanced to zero, and the power turned on again. The temperature reached was read off the dial in millivolts and recorded. Three runs of five grubs each were made; all at 3,000,000 cycles, one with a field strength of 2000 volts per inch, one at 4000 volts and another at 5895 volts. The results are set forth in Tables 1, 2 and 3. The heat increments in relation to one another are set forth in Figure 26.

TABLE 1. 3,000,000 FREQUENCY; 2,000 VOLTS PER LINEAR INCH

Date	Spec. No.	Start	30 Sec.	Increment	60 Sec.	Increment	90 sec.	Increment	Con.
12/24/32.....	1	2.15	2.25	0.10	2.35	0.10	2.40	0.05	Alive
12/24/32 ...	2	2.175	2.25	0.075	2.30	0.05	2.30	0.00	Alive
12/24/32 .. .	3	2.125	2.20	0.075	2.275	0.075	2.325	0.050	Alive
12/24/32 .	4	2.20	2.40	0.20	2.55	0.15	2.65	0.10	Alive
12/24/32 . .	5	2.20	2.25	0.05	2.325	0.075	2.35	0.025	Alive
Totals ..		10.850		0.500		0.450		0.225	
Average...		75°F		0.10=3.4°F		0.09=3.7°F		0.045=1.5°F	

The curves showing a consistent rise from beginning represent the actual rise of temperature in the insect body. The curves bending downward show the decreasing heat increments. The heat increments shown here represent, of course, the difference between actual internal heat production and heat radiation from the surface of the grub's body. Naturally, the speed of heat radiation increases as the internal temperature rises. This factor probably accounts, at least largely, for the decrease of the increments as shown in Figure 26.

In a study of thermal death point of this grub, with a frequency of 3,000,000 cycles, made July 13, 1932 it was found: (1) that the internal temperature immediately after death ranged from for 4000 volts 112°F to 104°F with an average of 107.3°F; (2) that for 4585 volts it ranged from 109°F to 104°F with an average of 107°F; that for 5240 volts it ranged from 107°F to 103°F with an average of 105°F. Heat radiation had a chance to occur after death and before the grub could be removed from the glass tube and the thermocouple inserted. The readings are, therefore, lower than the actual death point. In Table 2 the thermal death point occurs at about 3.2 millivolts or about 111°F.

TABLE 2. 3,000,000 FREQUENCY; 4,000 VOLTS PER LINEAR INCH

Date	Spec. No.	Start	30 Sec.	Inc.	60 Sec.	Inc.	90 Sec.	Inc.	120 Sec.	Inc.	150 Sec.	Inc.	180 Sec.	Inc.	Condition
12/23.....	1	2.125	2.35	0.225	2.65	0.30	2.875	0.225	2.95	0.075	3.075	0.125	3.1	0.025	Alive
12/23.....	2	2.25	2.70	0.45	3.025	0.325	3.25	0.225	3.45	0.20	3.60	0.15	3.675	0.075	Dead
12/23.....	3	2.25	2.525	0.275	2.85	0.325	3.05	0.20	3.20	0.15	3.375	0.175	3.525	0.150	Dead
12/23.....	4	2.075	2.275	0.200	2.375	0.100	2.575	0.200	2.90	0.325	2.95	0.05	3.0	0.05	Alive
12/23.....	5	2.05	2.20	0.15	2.30	0.10	2.375	0.075	2.45	0.075	2.55	0.10	2.55	0	Alive
Totals...		10.750		1.300		1.150		0.925		0.825		0.600		0.300	
Average..........		75°F		0.260 = 9.0°F		0.230 = 7.9°F		0.185 = 6.4°F		0.165 = 5.7°F		0.120 = 4.1°F		0.060 = 2.0°F	

TABLE 3. 3,000,000 FREQUENCY; 4,000 VOLTS PER LINEAR INCH

Date	Spec. No.	Start	30 Sec.	Inc.	60 Sec.	Inc.	90 Sec.	Inc.	120 Sec.	Inc.	150 Sec.	Inc.	180 Sec.	Inc.	Condition
12/23.....	1	2.175	2.575	0.400	2.90	0.325	3.20	0.30	3.375	0.175	3.45	0.075	3.55	0.10	Dead
12/23.....	2	2.10	2.65	0.55	3.05	0.30	3.30	0.25	3.45	0.15	3.65	0.20	3.725	0.075	Dead
12/23.....	3	2.175	2.75	0.535	3.10	0.35	3.225	0.125	3.325	0.10	3.40	0.075	3.55	0.15	Dead
12/23.....	4	2.075	2.85	0.775	3.225	0.375	3.50	0.275	3.80	0.30	3.95	0.150	4.10	0.15	Dead
12/23.....	5	2.175	2.65	0.475	3.05	0.40	3.15	0.10	3.175	0.025	3.25	0.075	3.35	0.10	Dead
Totals...		10.700		2.735		1.750		1.050		0.750		0.575		0.575	
Average..........		75°F		0.547 = 18.6°F		0.350 = 12.1°F		0.210 = 7.2°F		0.150 = 5.2°F		0.115 = 3.9°F		0.115 = 3.9°F	

Under a frequency of 3,000,000 cycles the length of time necessary to kill the third instar Japanese beetle grub, using a field strength of 2000 volts, has never been determined because heat radiation balances heat production long before the thermal death point can be reached. Under a frequency of 3,000,000 cycles the length of time necessary to kill when using a field strength of 4000 volts ranges from 90 seconds to more than 180 seconds. Under a frequency of 3,000,000 cycles, the length of time necessary to kill when using 5985 volts ranges from 60 seconds to a little more than 120 seconds with an average of 90 seconds.

At 4000 volts the time to kill is twice as long as the time to kill at 5895 volts while the field strength is only 1/3 less. Clearly, then, the economical and practical procedure is to increase the voltage to the point of prompt destruction of the insect.

Summary

1. Living organisms subjected to radio waves in the electrostatic field are primarily affected by the development of internal heat.
2. Electric energy pervading this field is absorbed by the organism and largely transformed into heat energy.
3. Internal heat accumulation occurs only when the rate of production overbalances the rate of heat radiation.
4. As the internal temperatures rise heat radiation increases
5. In the production of lethal effects it is a matter of prime importance that internal heat production shall be as rapid as possible.
6. This necessary rapid production of heat can be readily obtained by increasing the field strength as measured in volts per linear inch

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MR. L. M. PEAIRS: I should like to ask Mr. Headlee what the curve of the high voltage above the death point indicates.

MR. HEADLEE: The implications of that curve are not entirely clear to me, but I have never yet carried the internal temperatures high enough so that the heat increments when you are using high voltage entirely disappear.

I think there isn't any doubt that the same tissue in which the heat production takes place during the living condition will continue to produce heat for a period—how long, I do not know—following the death of the insect.

ECOLOGICAL STUDIES IN RELATION TO THE DISTRIBUTION AND ABUNDANCE OF ECONOMIC PESTS

By HARVEY L SWEETMAN, *Massachusetts State College*

ABSTRACT

Methods and techniques that can be used to obtain information from which forecasts of establishment, abundance, dispersal, control, and eradication of insect pests are discussed. Predictions of abundance and dispersal of several insects (cutworms, alfalfa weevil, Mexican bean beetle, etc) have been made that fit present known conditions. Controlled laboratory experiments, where climate is simulated, and quantitative data collected under natural conditions, together with correlative studies, afford a good means of analyzing and forecasting insect outbreaks. Probably quarantine regulations, and control and eradication measures against insect pests can be made more effective by means of such ecological investigations.

It is recognized by all entomologists that it would be very important and valuable to know in advance how abundant and injurious an insect pest was going to become. This holds whether the pest is a native or recently introduced species to the locality. When foreign pests are considered the need for advance information regarding the suitability of the new environment is very great. Ecological studies seem to offer a very important method of solving such problems (Bodenheimer, 1928; Blunck, 1930; Chapman, 1931; Cook, 1931; Escherich, 1930; Peterson, 1932; Uvarov, 1931). The thesis of this paper is a consideration of the available evidence and techniques which can be used to aid in answering the following questions:

1. Can the seasonal abundance and dispersal of established pests be forecasted?

2. Can non-established pests on other continents be subjected to ecological studies in their native habitat and forecasts of their probable establishment, abundance, and dispersal in the United States be made with a reasonable degree of accuracy?

3. Is it feasible to make quarantine regulations, suggest methods of control and eradication of non-established pests on the basis of ecological knowledge?

REVIEW OF THE EVIDENCE.—There are a few examples of insects being controlled by ecological methods in the field, and such control has been very successful in limited environments, such as in flour mills, grain elevators, greenhouses, and residences. The Hessian fly furnishes an outstanding example of control under field conditions, where a definite change in the environment results directly in control. In many

cases, however, knowledge of the responses of the insect to the environment are very important in aiding us to apply other control measures at the correct time. Fernald (1915) was able to predetermine the portions of Massachusetts where control measures against the elm leaf beetle would need to be applied. An understanding of the responses to the environment of the codling moth, red mites, apple maggot, and many other pests greatly enables us to plan our spray schedules to secure the maximum mortality of these pests with insecticides with the minimum cost.

While the demand for the ecological method for direct and accessory control is great, probably a more important phase is forecasting what is going to happen in the future. It has been said that forecasting, at best, is only a guess. However, the value of forecasting depends upon the percentage of accuracy, which must be high, that can be obtained.

Cook (1923, 1924, 1926, 1928) and Seamans (1923, 1928) have demonstrated that the distribution of certain cutworm moths can be fairly accurately predicted. Rather extended field and laboratory studies were made before reaching these conclusions. The abundance, in epidemic proportions, of some of the cutworm moths in any given year depends upon environmental conditions the preceding season or seasons. The outbreak of the pale western cutworm in Montana in 1932 verified the value of this method of prediction (Wall, 1932). When an outbreak of an insect is dependent upon the environment of the given season, forecasts are not so reliable since the seasonal weather conditions cannot be predicted accurately (Hinds, 1928). Cook (1925) predicted the probable dispersal of the alfalfa weevil in the United States entirely from a study of scattered items in the published literature on this insect. The present distribution of this pest has not passed the borders outlined, although it had reached some of the margins at the time Cook reviewed the subject (Cook, 1931). Severin (1924) and Carter (1930) were able to determine in advance when the migrations and outbreaks of the beet leaf hopper would occur. Predictions have been made regarding the spread and abundance of the Mexican bean beetle in the United States (Sweetman, 1929, 1930, 1932; Marcovitch and Stanley, 1930). It had been thought by a large number of entomologists previous to 1929, that the bean beetle had changed in its responses to environment. However, investigation revealed that the environment in the East was more suitable than the general climate of its native habitat in the Southwest (Sweetman, 1929). Bodenheimer (1929), in Palestine, has been able to make similar predictions for the migratory locust. Lean (1931) has

explained the migrations of a migratory locust in Nigeria on the basis of response to environment. Escherich (1930), in Europe, gives a review of results achieved in recent years in the correlation of climate with insect outbreaks.

Time alone will test the accuracy of these forecasts, but the examples cited indicate the general acceptance of this method of approach.

METHODS OF PROCEDURE.—Studies of the environmental effects on organisms can be conducted in the laboratory and under natural conditions. A combination of these methods seems to be the most promising.

Laboratory studies are usually more convenient and easier to conduct than field experiments, at least as far as comfort is concerned. They have the advantage also of being more accurately controlled. The organism can be subjected, as desired, to various environments planned to simulate the natural surroundings, or any extreme of conditions desired. The only limitations in modifications of conditions are equipment and the originality of the experimenter.

Usually temperature and moisture are very important factors in the environment. Both can be adequately controlled in the laboratory. Variable surroundings to simulate the natural conditions can be obtained by direct transfer from one environment to another or by variable control thermostats similar to the one described by Headlee (1929). Most of the important physical factors and some of the biotic factors of surroundings can be controlled as efficiently.

Field studies must be conducted with great care and perseverance. Such studies consist largely of actual observation and collection of quantitative data of the reactions of the organisms in their natural habitat, and correlative studies between results and possible causal factors. Correlations are suggestive only, and the conclusions cannot be accepted as final proof of the causal factor or factors. Numerous examples can be cited to illustrate the use of correlation between climatic factors and developments that have occurred in the past, but we are primarily interested in those instances only, where the correlations have been used to forecast future events. Two very good methods of approach in correlative studies are by use of the climatograph of Ball (1910) and the bioclimatograph of Uvarov (1932). The climatograph is being used widely by a number of workers in the United States, Europe, Asia, and Africa (Bodenheimer, Cook, Escherich, Lean, Murayama, Seamans, Sweetman, Tehon, *et al*). Cook (1931) has listed the steps involved in such correlative studies. Climatic maps such as those prepared by Thornthwaite (1931) and Kincer (1922, 1928) are extremely useful

also. The writer (Sweetman, 1932) has found such maps very helpful. Frequently field studies are not sufficiently detailed and continued long enough to give dependable results. Careful field studies may change the entire aspect of a field situation. At least, such studies must be made to avoid mere guessing. This is illustrated by observations of the May beetles in Minnesota (Sweetman, 1927, 1931). Nightly observations, continued from six to nine hours each night, were made during the entire flying season of several species. As a result it was shown definitely that the vegetative cover did not directly influence the places of oviposition of the beetles in Minnesota as had been previously supposed.

The types of ecological investigations suggested have been criticized because of the difficulty of intimately connecting field and laboratory studies. The gap between artificial and natural conditions is a wide one, but it can and has been bridged as noted above. However, there is much need of improvement in this field of research and ample opportunity is offered to the worker who has the originality to develop better technique.

SUMMARY.—It should be thoroughly understood by those interested in this discussion that the economic establishment, abundance, dispersal, control, and eradication of insects is under consideration. It is a much more difficult problem to determine the taxonomic limitations of a species as small ecoclimates, or even microclimates, may be suitable for the species to maintain itself, but not sufficient for the insect to become of economic importance.

Evidence is submitted showing that annual abundance and dispersal of some insects, especially those which require one or two seasons to build up to outbreak proportions, can be forecast, while pests which may reach epidemic numbers in any season, if the environment is favorable, present a more difficult problem.

Examples and methods of study are given that suggest means by which it is thought possible to predetermine the probable establishment, abundance, and dispersal of foreign pests that might be introduced.

The writer believes that quarantine regulations, and control and eradication measures against insects can be facilitated by means of the ecological approach.

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SPRAY TESTS FOR THE WHITE APPLE LEAFHOPPER, *TYPHLOCYBA POMARIA*

By W J SCHOENE, *Entomologist, Virginia Agricultural Experiment Station*

ABSTRACT

This is a report on spray experiments for the control of the second brood of the white apple leafhopper on apple trees Nicotine combined with Penetrol or summer oil was effective

Spray tests for the white apple leafhopper, *Typhlocyba pomaria,* were conducted in two orchards One consisted of bearing trees fifteen years old, the other was an adjoining block of five year old trees. Between the 20th and 25th of August the visible leafhopper population consisted almost entirely of nymphs This made it possible to greatly reduce the number of insects with a single spray application. The bearing orchard in which these tests were carried on consisted of rather large fifteen year old trees and the varieties sprayed were heavily loaded with fruit. The

trees carried abundant foliage which made thorough spraying difficult. A few of the trees in the young orchard were selected for treatment with a hand sprayer. These trees were about five years old, and mostly without fruit. They were small enough so that the entire tree could be sprayed from the ground and seriously infested with leafhopper nymphs.

The orchard was visited June 22, 1932. There was a heavy leafhopper infestation, the first brood adults being present in large numbers. At this date the nymphs had practically disappeared. The apples were slightly specked and there was some foliage injury. No parasitized adults were noticed. Since the insects were in the adult stage, spraying operations were postponed until the appearance of the second brood nymphs. The orchard was visited again August 15. There was a heavy infestation of nymphs. Most of them were just hatching but a few third and fourth-stage nymphs were present. The nymphs could be found on every leaf, twelve to fifteen to a leaf, and as high as forty nymphs were found on some leaves. Most of the Delicious and Ben Davis trees were loaded with fruit. The Fallawater trees had a moderate crop. The other varieties in this orchard had no fruit or a very light crop. These varieties included York Imperial, Stayman Winesap, and Mammoth Black Twig.

Materials used on bearing trees.

PENETROL AND BLACK LEAF 40

Penetrol	½ gal.
Nicotine	½ pt.
Water to make 100 gals	

SUMMER OIL AND BLACK LEAF 40

Oil	1 gal.
Nicotine	¾ pt.
Water to make 100 gals.	

The spraying was started August 22, using Penetrol and Black Leaf 40. At this time the nymphs were mostly in the 1st, 2d, and 3d stage with a very few 4th and 5th stage individuals and some adults. The apples were just beginning to take on color. The dense foliage made it difficult to thoroughly spray the heavily loaded trees and a number of trees were sprayed before the operators acquired the knack of wetting the undersurface of all the foliage. The tree was sprayed first from the inside. The person holding the nozzle would have to crawl under the branches because the trees were headed low. After the underside was sprayed the operator walked around the tree spraying the upper surface of the foliage from the outside. Between nine and ten gallons were required for each tree. The spray was applied at a pressure of 350 pounds. The Penetrol and nicotine combination killed all of the nymphs that were wet with the spray and also many adults. Subsequent counts indicated that 94% of the nymphs were

killed. Five tanks or 1000 gallons of the Penetrol-Black Leaf 40 spray were sufficient to cover 105 trees. This application was completed on August 22 and 23.

The operations were interrupted for several days but started again on August 27 and continued to August 31. Summer oil and nicotine was used in the proportion of one gallon of oil and ¾ pint Black Leaf 40 to each 100 gallons of spray. Five thousand gallons were required for the remaining trees. During this period the leafhopper nymphs continued to develop and some changed to adults. No difference was noticed in the effectiveness of the oil-nicotine and the Penetrol-nicotine combination. The trees sprayed with summer oil and nicotine had a slight oily appearance but no injury was noticed. The trees that were sprayed with the above combinations held their foliage and the apples attained normal color. The Stayman Winesaps and Mammoth Black Twig varieties which were not sprayed and which had very little fruit began to lose their foliage by September 1 and by the fourteenth of September had lost from 25 to 50% of their leaves. The apples on these trees had a peculiar brownish color instead of normal red color.

To determine the limit of effectiveness of the nicotine on nymphs, a number of small trees in the five-year-old orchard located adjacent to the bearing orchard were sprayed with various combinations using a 4-gallon compressed air sprayer. The trees sprayed were sufficiently small so that the entire tree could be sprayed from the ground. The following combinations were tested in this manner:

SUMMER OIL

Oil 1 to 100	Effective for 1st, 2d, and 3d stage nymphs
Oil 2 to 100	Effective for 1st, 2d, and 3d stage, a few 4th and 5th stage nymphs killed

SUMMER OIL AND BLACK LEAF 40

Oil ½ to 100 Nicotine 1 to 1600	Adults and some 5th stage nymphs escaped. 100% effective for other stages.
Oil 1 to 100 Nicotine 1 to 1000	Very effective, no nymphs alive Many adults killed

PENETROL AND BLACK LEAF 40

Penetrol ½ to 100 Nicotine 1 to 1000	Very effective. A few adults escaped. All nymphs killed.
Penetrol ½ to 100 Nicotine 1 to 2000	Very effective. 100% of nymphs and most adults killed
Penetrol ½ to 100 Nicotine 1 to 4000	Effective in killing young nymphs. Some 5th stage nymphs escaped. A few adults killed.

Judging from these tests, it appears that the nicotine and Penetrol combined, containing Penetrol in the proportion of ½ to 100 and nicotine 1 to 2000 could be depended upon to control all of the nymphs hit with the spray. The summer oil without nicotine was also effective against the young nymphs and is deserving of further trial. It should be explained, however, that in applying the spray to these small trees an effort was made to spray both the upper and lower surfaces of every leaf on the tree, and in the attempt to be thorough many of the leaves were sprayed until the leafhoppers were submerged in the liquid.

CONCLUSION.—It is concluded that the second brood of the white apple leafhopper can be controlled by a single treatment of nicotine and oil if the application can be made while the insect is still in the nymph stage. The combinations of nicotine and summer oil or nicotine and Penetrol proved effective against the nymphs and caused no injury to the fruit or foliage. Drenching the foliage with one per cent summer oil was effective for the 1st, 2d, and 3d stage nymphs.

MR. C. J. DRAKE: I should like to ask Professor Schoene what control he got with summer oil in nicotine.

MR. SCHOENE: I could not see any difference in the control with summer oil with the nicotine and the Penetrol combination. We used the nicotine a little stronger where we used the summer oil, but we killed all the nymphs we hit with the spray.

When the trees were heavily loaded with fruit and the foliage was very heavy on these trees, it was necessary for the man to get underneath the trees in order to spray them. We got pretty fair control.

MR. PHILIP GARMAN: I should like to ask Professor Shoene if he made any tests of nicotine without oil.

MR. SCHOENE: I have made no such test on foliage attached to trees. Several years ago I tested different dilutions of nicotine with and without oil on infested twigs. I cannot give you offhand the results. The soap or oil adds very considerably to the effectiveness of the nicotine.

MR. GARMAN: That was my impression of the experiments running heretofore. We ran a series of experiments this year at the Connecticut Station and these experiments were conducted on trees of about the same size that you showed on the screen, using both soap, (dry, three pounds) and nicotine (one pint to one hundred gallons) without soap,

making the comparison of the nymphs per hundred leaves before and after. In neither case was there any increase from the addition of soap.

MR. P. J. PARROTT: In New York we have the same problem, but in view of the importance of the apple maggot we are compelled to use nicotine with whatever is used as a fungicide. We have been carrying on experiments with dry mix and lime sulphur to carry the nicotine, making the application for the first generation of nymphs, and the treatment in September, using these two fungicides. We secured excellent results.

MR. S. W. FROST: A number of years ago we reported some work with nicotine dust and got a very high percentage of kill when the temperature was high. When the temperature dropped, our percentage of kill fell off to a marked degree.

At that time we measured our leafhoppers chiefly by volume as well as making counts on foliage. It was surprising. We would get as much as one quart of leafhoppers from one highly infested tree. I would think the same would hold true where nicotine sprays were used alone without active agents.

PRESIDENT FLINT: You said high temperatures. What were the high temperatures?

MR. FROST: Temperatures of between 85 and 90. As a matter of fact, we selected the afternoon following, say, at one o'clock on sunny days when the temperatures were usually at their height during the day. We reported excellent kill and then when fruit growers tried it they were very careless about selecting that portion of the day and selecting sunny days, and the results, as commercial control, were of little or no value.

NOTES ON BREEDING *MACROCENTRUS ANCYLIVORUS* FROM REARED HOSTS

By Philip Garman

Abstract

Oriental fruit moth eggs are obtained in a greenhouse incubator regulated to 75° to 80°F. at sundown. Green apples obtained in orchards at thinning time are used for feeding larvae. Hibernation is prevented by bringing all stock indoors in August and breeding at 75° or above. Nearly a million and a half fruit moth eggs were obtained in 1932. Optimum air conditions for *Macrocentrus ancylivorus* are considered to be 70 to 75°F and 40 to 80 per cent relative humidity. Methods of handling have considerable influence on the sex ratio Host larvae five days old at 80°F. are used for exposure to parasites. Successful hibernation of Macrocentrus is not fully solved, but about 36,000 were bred in 1932 The general procedure is given.

Successful breeding of *Macrocentrus ancylivorus* depends upon breeding its host in sufficient quantities to make it available at all times. There must be a sufficient ratio of host increase so that it will continue to be available and not be exhausted by losses from parasitism. It may be of interest to outline some of our work with the Oriental fruit moth, the host we are now using, and methods employed to breed them in quantities.

The Host.—It is, of course, necessary to secure fertile eggs in large numbers. To do this the moths are confined in a cloth cage enclosed in a celotex incubator. The cage is so constructed that all woodwork is covered on the inside with cloth. It rests in a pan of moist sand. Wicks supply moisture directly to the top of the cage and extra pans of water are used within the incubator to raise the humidity. Peach seedling trees are put in the cage with the leaves in direct contact with the top where most of the moths congregate. A glass window in the top of the incubator supplies light which, because other light is excluded, aids in collecting the moths above the trees. Most of the eggs are laid after the light begins to fade or in midwinter between three and five P. M., in summer considerably later. We do not use the incubator in summer but continue to hold the moths in the greenhouse even though the temperature is fairly high. However, as soon as the nightly temperature begins to drop below 60°F. the egg deposition cages are shifted to the incubator, and the heat turned on during egg-laying periods. We aim to keep the temperature up to 80° during these periods and the humidity as high as possible.

It is not enough, however, merely to secure eggs in quantities. The larvae must be carried to maturity with a minimum of loss. Green immature apples collected in commercial orchards at thinning time are used and such fruit may be kept in storage throughout the year. Tests show that a larger per cent of larvae mature in green apples than in ripe fruit. Seedling peach twigs are unsatisfactory because they are not large enough for the larvae to mature, and greenhouse grown peach seedling tips frequently exude gum and destroy the larvae. It is, therefore, necessary to transfer the twigs to apples when the larvae are quite young and other losses result in this operation The only advantage of this method lies in the ease of obtaining a fairly high parasitism, but the disadvantages already mentioned more than offset this advantage.

Another point which appears important if breeding is to continue during the winter is prevention of hibernation in the case of the larvae. Larvae of the fruit moth reared at New Haven begin to show tendencies to hibernate in August. The percentage increases gradually until all reach this stage. To avoid such a condition it is apparently necessary with us to bring the stock indoors about the first of August and breed at temperatures above 70°F., preferably above 75°. We have done this for two successive years and the stock breeds continuously from generation to generation, with only a small percentage of hibernation. Table 1 gives some production records of the Oriental fruit moth during 1931 and 1932.

TABLE 1. EGG PRODUCTION OF THE ORIENTAL FRUIT MOTH

1931	Moths	Eggs	1932	Moths	Eggs
January...	514	4,773	January	2,956	81,817
February...	321	3,358	February	4,540	96,320
March	2,706	40,000	March	6,030	112,960
October	4,969	63,243	October	4,746	66,900
November....	3,583	54,538	November	3,951	81,036
December	1,371	39,160			

The total egg yield was more than 630,000 in 1931 and 1,413,000 in 1932, up until the first of December. Moth production in 1932 up until December 1 was 141,421. Daily production is averaging at this time (December 15) about 3,000 a day and the greatest number produced in any month was 234,000 in June, 1932.

THE PARASITE.—It is also essential to provide suitable air conditions for the parasite considered. So far as we have been able to determine, temperatures between 65 and 75°F. are most suitable for oviposition, while 70 to 80° are apparently best for mating. This leaves 70 to 75° as optimum conditions for satisfactory increase and we have obtained

best results when temperatures were adjusted to this range. A humidity of about 70 per cent is desirable, although satisfactory results have been obtained with a range of 40 to 80 per cent. Humidities above 90 per cent are not desirable because the parasites become sluggish and show little disposition to seek larvae for oviposition. The outside limits of temperature permissible are around 60° and 85°F. If the temperature goes to 90°, mortality is very rapid with the ratio of increase naturally lowered, and the same is true if the temperature goes much below 60° for any length of time. It has been found by others that the adults will oviposit at night when there is no light. We have also noted this point in our cages, but find that oviposition at night is better if a feeble light is kept burning over the cage. This is especially desirable in winter when the days are short and twilight periods abbreviated. A 25 W blue daylight bulb is used, and one light is enough for a number of cages. We make use of a greenhouse bench incubator for keeping the temperature, light and humidity satisfactory, but there are some disadvantages in this location, one of which lies in the inability to prevent too high temperatures. During three-fourths of the year, however, we have little or no trouble.

It is apparently more difficult than supposed to secure properly mated females for quantity breeding. Experiments (Table 2) will indicate that females placed in a cage on emergence from the cocoon with an equal number of males are not always satisfactory for production. Those mated with a large excess of males are better. We have, however, maintained a fairly good increase even when the sex ratio was two males to every female, but it is desirable to obtain a better ratio if possible (the normal ratio is considered to be one male to 1.5 females, or about 40 per cent males). In our cages a single female will parasitize 10 to 15 larvae in the course of 24 hours, at the height of her egg-laying period. After the peak, daily parasitism is much less.

TABLE 2. EFFECT OF DIFFERENT TREATMENTS ON THE PERCENTAGE OF MALES

	Sex in exposure cage	No. reared	Per cent males	Dates
Males = females—1 day in mating cage .	females	338	70	Feb. 9–16
Males = females—2 days in mating cage	females	457	70	Feb. 9–16
Males > females—1 day in mating cage	females	757	56	Mar. 5–26
Males = females—1 day in mating cage	females	575	81	Mar. 6–26
10 known mated females	females	128	46	May 5–21
10 females from screen with excess males	females	165	52	May 5–21
10 known mated females	females	263	38	Nov. 1–15
10 males = 10 females	both	434	63	Nov. 1–21

Having secured suitable air and other conditions for mating and oviposition, it appears of importance to supply the host material in quan-

tity and of the proper age. To obtain a large number of larvae, say in the second or third instar, fruit moth eggs are placed upon apples and kept in a constant temperature incubator at 80° for four to five days. In this way larvae for oviposition are not too old or too young and with a daily fruit moth egg production of 3,000 it is fairly simple to obtain them in quantities.

One of our greatest difficulties lies in satisfactorily carrying material in hibernation after it is parasitized. This problem is not yet solved and our losses have been very great. We know that Macrocentrus larvae successfully passing the winter do so in the first instar. It has also been stated by Fink[1] that unhatched eggs may be destroyed by the host in the course of the winter. It is apparently necessary therefore to allow the maximum number of parasite eggs to hatch into first instar larvae and a progressive lowering of the temperature is probably necessary. Direct transfer from breeding pans to full hibernating temperatures (38–40°F.) was too drastic judging from our experience in 1932. To overcome this difficulty we continued to breed in winter and spring and succeeded in obtaining about 7,500 surplus in June. During the year, however, nearly 37,000 were reared, leaving about 30,000 for breeding stock. There are possibilities, therefore, in artificial production of this parasite of the Oriental fruit moth. Table 3 gives our monthly emergence in 1932.

TABLE 3. MACROCENTRUS ADULTS OBTAINED IN 1932

January	1,618	July	2,887
February	2,203	August	3,735
March	3,632	September	2,809
April	3,581	October	2,139
May	4,476	November	2,135
June	7,639		
Total			36,854

Our general procedure is as follows:

1. Secure stock of green apples thinned from commercial orchards in June and July and place in cold storage. (It is assumed that a stock of Oriental fruit moths are available).

2. Move all host stocks indoors in August. Do not allow the temperature to fall below 70°F.

3. Obtain eggs in 80° incubator closed and humidified during the late afternoon, using potted peach seedlings in contact with the top of the cage.

4. Place 2,000–4,000 eggs daily on a 12 to 15 inch pan of sliced green apples, and keep each pan at 80° for 4 to 5 days before using.

[1]Jr. Agr. Research, 32: p. 1134. 1926.

5. Separate slices and hang in parasite cage about one inch from the top. Regulate temperature to 70–75°F.

6. Place Macrocentrus adults in each parasite cage daily. Remove parasititzed larvae in apple slices daily (replacing with fresh stock) and keep in breeding room at 75° or above. Hibernating stocks may be kept at a lower temperature.

7. After several days add fresh apples to accommodate larvae leaving the original slices and provide corrugated paper strips for spinning and pupation.

8. Remove strips with larvae and keep for emergence or place in hibernation.

9. Watch for ants or other enemies and apply control measures as soon as they appear in the vicinity of breeding cages. Screen breeding pans for control of secondaries in rearing rooms

SUMMER OIL EMULSIONS AGAINST THE ORIENTAL FRUIT MOTH AND OTHER INSECTS[1]

By S. W. Frost, *The Pennsylvania State College*

Abstract

Laboratory tests with two per cent oil emulsions, under severe conditions, did not give the kill noted in the investigations of 1931.[2] Several commercial oil emulsions have been used without injury on peach and apple The same oils, in combination with sulphur, have been used on peach and in combination with 3–3–50 Bordeaux, on apple, without injury Two per cent oil emulsions without lead arsenate gave no control of codling moth. A five per cent oil impregnated lead, sulphur, lime dust gave considerable reduction of oriental fruit moth injury.

Spray Tests on Individual Fruit at the Laboratory.—Peaches were sprayed from four angles with a hand machine using 150 pounds pressure. The fruits were hung on racks and the spray material allowed to dry for at least twenty-four hours before eggs, ready to hatch, were fastened to them. The eggs therefore were not sprayed but the young larvae on hatching came in contact with the oil. At the end of three weeks the fruits were removed from the racks and cut to determine the percentage wormy. In tests 1 and 2, glass microscope slides were wired to the sides of the peaches as a substitute for foliage. The oils were not absorbed by the glass as they were by foliage and the percentage kill was higher in these tests. The slides were discarded in

[1]Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 573.

[2]Frost. Jl. Econ. Ent. 25, No. 2. 1932.

tests 3 and 4. In test 1, 2 and 3 the fruits were sprayed and hung in the laboratory until the peaches were finally cut. In test 4, the fruits were sprayed out of doors and were left there for 3, 6 and 9-day periods respectively when they were brought into the laboratory and eggs were clipped onto them.

A two per cent oil emulsion sprayed on glass slides, killed a very high percentage of newly hatched oriental fruit moth larvae within a period of forty-eight hours; 90.9% and 96.7% kill in test 1 and 96.7% kill in test 2. These results are comparable to those obtained in 1931.[2] When glass slides were discarded, the percentage kill fell to 50% or less. In experiments where eggs were fastened to the fruit, three six and nine days after being sprayed with oil emulsion, the kill was reduced to 30 per cent or less. Neither of these tests are entirely fair. Glass slides as a substitute for foliage is artificial and undoubtedly gives an abnormally high percentage of kill. The attachment of eggs directly to the fruit is unnatural because the oriental fruit moths do not oviposit on peach but upon the foliage and the young larvae must wander a considerable distance to reach the fruit. The figures for 1932 (Table 1) are sufficient to indicate that one and two per cent oil emulsions after a two or three day period give a comparatively low percentage of kill of newly hatched oriental fruit moth larvae.

A test conducted with peach twigs showed even a lower percentage kill of newly hatched oriental fruit moth larvae. One hundred peach twigs were sprayed with one per cent Ortho K on May 20. The following day an egg, ready to hatch, was attached to each peach twig. On May 31, all of the twigs were examined: 88 were infested and 12 uninfested, showing that 88 per cent of the oriental fruit moth larvae succeeded in gaining entrance to the twigs.

These investigations do not take into consideration the effect of one or two per cent oil emulsions on the eggs of the oriental fruit moth. There is no doubt that oil emulsions sprayed directly on the eggs will give a high percentage of kill.

Tests Against the Eggs of the Red-Banded Leaf-Roller.—The following test was directed against the summer eggs of the Red-banded leaf-roller (*Eulia velutinana*). The eggs were laid in rearing jars in the insectary upon cellophane. Small pieces of the cellophane bearing batches of eggs were cut, fastened to a board and sprayed.

Two small tests were conducted using one and two per cent Verdol against the Red-spider (*Paratetranychus pilosus*). Branches of apple, about four feet long, with a moderate infestation of red-spider were cut

TABLE 1. TESTS AGAINST NEWLY-HATCHED ORIENTAL FRUIT MOTH LARVAE ON PEACH

Treatment	Notes[1]	Number of peach	Peach sprayed	Eggs clipped on peach	No. of larvae entering fruit	Per cent clean fruit
Test No. 1—June 16–July 1, 1932						
1% Ortho K........	Slides[1]	120	June 16	June 17	11	90.9
2% Ortho K...... ..	Slides[1]	119	June 17	June 18	4	96.7
Checks[2]............	——	115	——	June 16	107	7.0
Checks[3].......	——	114	——	——	0	100.0
Test No. 2—July 7–28, 1932						
2% Fish oil emulsion	Slides[1]	114	July 9	July 10	74	35.1
2% Ortho K	Slides[1]	119	July 7	July 9	4	96.7
2% Ortho K........	Slides[4]	115	July 8	July 9	42	63.5[4]
2% Cottonseed.....	Slides[1]	115	July 8	July 9	5	95.7
Checks[3].......... ..	——	120	——	——	0	100.0
Test No. 3—August 3–23, 1932						
2% Ortho K	Leaves[1]	114	Aug. 3	Aug. 4	39	65.8
2% Ortho K... . ..	——	119	Aug. 3	Aug. 4	53	55.5
2% Ortho K........	——	115	Aug. 4	Aug. 7	56	51.3
2% Ortho K........	——	115	Aug. 4	Aug. 9	70	39.2
Checks[3]	——	120	——	——	1	99.1
Test No. 4—September 9–28, 1932						
2% Ortho K	——	114	Sept. 9	Sept. 12	82	28.1
2% Ortho K.	——	119	Sept. 9	Sept. 15	79	36.4
2% Ortho K...... ..	——	115	Sept. 9	Sept. 18	77	33.1
Checks[3]	——	115	——	——	12	89.6
Checks[3]	——	120	——	——	15	87.6

[1]In a few cases microscope slides or leaves were fastened to the sides of the peach.
[2]Eggs, ready to hatch, clipped to the fruit.
[3]No eggs clipped to fruit.
[4]In this case the microscope slides were not sprayed, in the other cases slides and peaches were sprayed.

from a nearby orchard on July 20, brought to the laboratory and sprayed immediately with summer oil emulsions using a hand pump and 150

TABLE 2. EFFECT OF 2% OIL EMULSION ON THE EGGS OF THE RED-BANDED LEAF-ROLLER

Treatment	Number of batches	Number of eggs	Per cent kill
2% Ortho K	12	372	100.00
Check....................................	12	334	10.00[1]

[1]Unfortunately there was a large percentage of infertile eggs.

pounds pressure. On July 22 counts were made of live and dead red-spiders as follows:

TABLE 3. EFFECT OF SUMMER OIL EMULSION AGAINST THE RED-SPIDER

Material	Number of leaves examined	Live red-spiders	Dead red-spiders	Per cent kill
1% Verdol......................	100	1	494	99.8
2% Verdol......................	100	6	581	99.0

Table 4 Tests With Summer Oils on 3 Year Elbertas

Tree	Number[1] applications	Materials	Foliage injury on dates indicated: June 1	June 21	July 1	July 11	July 20	Nov 1
25	4	2% Ortho K	None	None	None	None	None	None
26	4	2% Ortho K and Koloform	None	None	None	None	None	None
22	4	2% Meedol	None	None	None	None	None	None
23	4	2% Meedol and Koloform	None	None	None	None	None	None
24	4	2% Meedol "L"	None	None	None	None	None	None
20	4	2% Meedol "L," Koloform	None	None	None	None	None	None
11	1[1]	1% Texide	Considerable	Considerable	Considerable	Considerable	Considerable	Still evident
5	3	Sod. Al. Fluoride Kalo	——	None	None	None	None	None
8	3	Sod. Al. Fluoride Kalo	——	None	None	None	None	None
9	3	Sod Al Fluoride Pa. Salt Co	——	None	None	None	None	None
14	3	Sod Al. Fluoride, Pa Salt Co	——	None	None	None	None	None
19	3	2% cotton seed emulsion	——	None	None	None	None	None
17	2	2% flax seed oil emulsion[3]	——	——	None	None	None	None
4	2	2% Meedol "a"	——	——	None	None	None	None
16	2	2% Nicona	——	——	Trace	Trace	Trace	Not evident
27	2	1% Texide	——	——	None	None	None	None
15	2	2% Texide	——	——	Considerable	Considerable	Considerable	Considerable
12	1	2% Linseed oil emulsion	——	——	——	——	Slight[2]	Slight[2]
13	1	2% Fish oil emulsion	——	——	——	——	Slight[2]	Slight[2]
45	1	2% Verdol	——	——	——	——	None	None
46	1	2% Verdol and Koloform	——	——	——	——	None	None

[1]Applications were made on May 25, June 10, June 22 and July 14, where less than four applications, these were made on the later dates except tree No. 11 which was sprayed on May 25

[2]Merely discoloration of the foliage, no burned areas through the leaves

[3]Sherwin Williams flax seed soap at the rate of 1 lb 6 oz to 100 gals of water

Spray Tests with Summer Oils on Peach and Apple.—These tests were performed to determine the limits of safety in applying summer oil emulsions alone and in combination with fungicides. Three and seven year old trees were selected near the laboratory where results could be studied carefully. The materials were applied with a hand pump with 150 pounds pressure using from one to two gallons per tree. As a matter of fact the trees were thoroughly drenched and where slight injury is noted probably none would have resulted under normal spraying.

Four successive applications were made to three year old Elbertas on May 25, June 10, June 22 and July 14. Trees Nos: 15, 16, 17, 18, 20, 21, 22, 23, 24 and 26 received oil sprays the preceding year. In 1932, commercial summer oils were used as indicated in Table 4. Koloform was used at the rate of ten pounds to one hundred gallons of mixture. Linseed oil, fish oil and cottonseed oils were emulsified with American Cyanamid Company spreader No. 235 using four ounces to one hundred gallons of water.

Warm and cool days were selected for the applications. The mean temperatures for the days of application and the following two days were as follows:

May 25–26–27 mean temperature 72.5° F.
June 10–11–12 mean temperature 62.5° F
June 22–23–24 mean temperature 71.3° F
July 14–15–16 mean temperature 75.0° F

The temperature for May 25–26–27 was exceedingly high for this season of the year while the temperature for June 10–11–12 were somewhat low. The weather following the applications was generally clear. An inch of rain occurred on the evening of June 11 and a quarter of an inch of rain on the evening of June 15.

It is evident from Table 4 that most of the commercial oil emulsions can be used with safety on peach, even in combination with sulphur. The injury noted for trees 12, 13 and 16 was very inconspicuous, the foliage was merely discolored, no burned holes appeared in the leaves. Injury is more liable to occur early in the season when the foliage is tender. One per cent Texide gave considerable injury when applied on May 25 resulting in the typical shot hole appearance of the foliage but practically no injury resulted when 1 per cent Texide was applied on June 22 and June 24. Spraying was discontinued on July 14 largely because the trees were planted close together and they had made such luxuriant growth that it was difficult to get around them with the spray machine. At the end of October the foliage was dark green and the

TABLE 5. TESTS WITH SUMMER OILS ON FIVE TO SEVEN YEAR APPLE TREES

Tree	Applications	Materials[2]	Foliage injury on dates indicated: May 26	June 13	June 21	July 11	Aug 1	Nov 1
29	Four[1]	2% Texide	Slight injuring	None[3]	None	None	None	None
30	May 25	2% Texide Lime-sulphur 2	Serious defoliation	Recovered	———	———	———	———
31	Four[1]	2% Meedol	None	None	None	None	None	None
32	May 25	2% Meedol L. sulphur	Slight defoliation	Recovered	———	———	———	———
34	Four[1]	2% Ortho K	None	None	None	None	None	None
33	May 25	2% Ortho K L. Sulphur	Slight defoliation	Recovered	———	———	———	———
27	Four[1]	2% Ortho K Bordeaux	None	None	None	None	None	None
28	Four[1]	2% Ortho K Bordeaux	None	None	None	None	None	None
40	June 24	1% Texide	———	———	None	None	None	None
41	June 24	2% Texide L. Sulphur	———	———	———	Slight burning	Slight burning	No defoliation
42	June 24	2% Ortho K L sulphur	———	———	———	Slight burning	Slight burning	No defoliation
43	July 14	2% Fungona R	———	———	———	———	None	None
44	July 14	2% Fungona N	———	———	———	———	None	None

[1]Applications made on May 25, June 10, June 22 and July 11

[2]Lime sulphur 6 gallons to 100 on tree 30, 3 gallons to 100 in other cases Bordeaux 3-3-50 added to oil emulsion Koloform used at rate of 10 lbs. to 100 gallons.

[3]No injury due to the later applications.

trees looked exceedingly healthy. Some of the trees had 36 inches of new growth.

A number of different applications of summer oil emulsions were made on apple. The trees, chiefly York Imperial, varied from five to seven years old. Bordeaux 3–3–50 and Lime Sulphur, 3 and 6 gallons to the hundred, were added to the oil sprays on several occasions. Fungona R and Fungona N were not received until late in the season and did not permit a fair trial. These are summer oil emulsions with the addition of fungicides.

Tree No. 34 received four applications of oil emulsions in 1931; 3 per cent Red engine oil on April 27, 1 per cent Texide on June 26, 1 per cent Texide on July 1 and 2 per cent Texide on July 10. No injury resulted in 1931 and after the application of four sprays of 2 per cent Ortho K in 1932, the tree looked fine on November 1. (See Fig 1).

Tree No. 83 received two applications of oil in 1931; 3 per cent Red Engine oil on April 27 and 3 per cent Ortho K on July 1. No injury resulted in 1931. In 1932 the combination of 3 gallons of Lime-sulphur to 100 gallons of water and 2 per cent Ortho K caused slight defoliation from which the tree recovered later in the season

Other tests were conducted that are not shown in Table 5. A mixture of one gallon of Ortho K, 2½ gallons of lime-sulphur and 3 pounds of arsenate of lead was sprayed May 14 on a 12 year old York Imperial, a 15 year old Summer Rambo, a cherry tree, an old and a young Bartlett pear tree. No injury resulted on the cherry or the two apple trees but the two pear trees showed slight traces of burning.

Tests with Oil Emulsions in a Commercial Peach Orchard.—A number of summer oil emulsions were applied to fifteen year old Elbertas using a Bean sprayer with 350 pounds pressure. Two trees were sprayed with each of the oils or oil-fungicide combinations. No arsenate of lead was used in these tests. Koloform was used at the rate of ten pounds to one hundred gallons of mixture. The applications are summarized in Table 6.

An excellent crop of peach was picked from the Raffensperger Orchard. At picking time the foliage looked excellent and there was no indication of burning or injury to the fruit. Table 7 also shows that there was no reduction in percentage of oriental fruit moth.

Tests with Oil Emulsions in a Commercial Apple Orchard.—A block of sixty fifteen year old York Imperial trees was selected for testing various oil emulsions and oil-fungicide combinations. Six trees

in adjoining rows were treated with materials as indicated in Table 8, using a Bean sprayer with 350 pounds pressure. The trees were not

TABLE 6. SUMMARY OF OIL TREATMENTS ON 15 YEAR ELBERTAS.—RAFFENSPERGER ORCHARD 1932

Plot[1]	May 28	June 20	July 14	Aug. 2	Foliage injury	Fruit injury
1	1% Ortho K	2% Ortho K	2% Ortho K	2% Ortho K	None	None
2	1% Ortho K Koloform	2% Ortho K Koloform	2% Ortho K Koloform	2% Ortho K Koloform	Very slight[2] indication of	None
3	1% Meedol	2% Meedol	2% Meedol	2% Meedol	None	None
4	1% Meedol Koloform	2% Meedol Koloform	2% Meedol Koloform	2% Meedol Koloform	Very slight[2] indication of	None
5	1% Meedol "L"	2% Meedol "L"	2% Meedol "L"	2% Meedol "L"	None	None
6	1% Meedol "L" Koloform	2% Meedol "L" Koloform	2% Meedol "L" Koloform	2% Meedol "L" Koloform	None	None
7	Self-boiled lime sulphur applied May 18 and June 27				None	None

[1]Two trees in each plot.
[2]While injury is noted here, it was so slight that it was barely noticeable. Only one of the two trees in each case showed injury and these trees had evidence of being considerably weaker than the other trees. None of the trees in this experiment were fertilized during the current year as they were to be removed at the end of the season.

large and the spraying was done from the ground with a gun. Drop fruit was gathered once a week from every one of the trees starting on June 11 and continuing until picking time so that the entire crop from the six trees in each plot was examined and tallied.

TABLE 7. SUMMARY OF ORIENTAL FRUIT MOTH INJURY ON ELBERTA RAFFENSPERGER ORCHARD 1932

		Thinned fruit[2]		Picked fruit		
Plot	Treatment[1]	No. fruit	Per cent wormy	No. fruit	Per cent wormy	Spray injury
1	Ortho K...........	22	3.3	934	5.6	None
2	Ortho K Koloform..	200	2.5	612	6.3	None
3	Meedol............	200	2.5	842	7.6	None
4	Meedol Koloform...	100	4.0	835	7.6	None
5	Meedol "L"........	200	4.0	728	6.8	None
6	Meedol "L"........	200	3.0	878	5.3	None
7	S. boiled L. sulphur	200	5.5	1,560	2.9[3]	None

[1]For mixture see Table 6.
[2]Only a part of the thinned fruits were examined except plot 1 which had a light crop on tree selected for counts.
[3]This discrepancy is due to the fact that on Aug. 2, wormy fruit was thinned from plot 7 but not from the other plots.

All the trees received a pink application of lime-sulphur at the rate of two gallons to one hundred of water. No petal-fall was applied. The first, second, third and fourth cover sprays were applied as indicated in Table 8.

TABLE 8. SUMMARY OF OIL TREATMENTS IN COMMERCIAL YORK IMPERIAL ORCHARD 1932[2]

Plot[1]	1st Cover May 28	Foliage injury from 1st cover	2nd Cover June 20	3rd Cover July 14	4th cover Aug. 2	Foliage injury from 2, 3, 4 covers
1	1% Ortho K	None	2% Ortho K	2% Ortho K	4% Ortho K	None
2	1% Ortho K Koloform 12½–100	Considerable	2% Ortho K Bordeaux 3-3-50	2% Ortho K Bordeaux 3-3-50	4% Ortho K	None
3	1% Meedol	None	2% Meedol	2% Meedol	4% Ortho K	None
4	1% Meedol Koloform 12½–100	Considerable burning	2% Meedol Bordeaux 3-3-50	2% Meedol Bordeaux 3-3-50	4% Ortho K	None
5	Koloform 12½–100 A-lead 4–100[3]	None	Koloform 12½–100 A-lead 4–100[3]	Koloform 10–100 A-lead 4–100[3]		None

[1]Six trees in each plot.
[2]A pink application was made to all plots with L-sulphur but without arsenate of lead. The petal-fall was not applied to any of the plots.
[3]Basic arsenate of lead.

The injury in plots 2 and 4 was due to the sulphur-oil combination, the burning was of the sulphur type with no indication of the oil type of burning. The injury occurred only on one side of the trees, that from which the wind was blowing at the time of the application of the oil-Koloform treatment. This indicates that the burning was due largely to a drenching of the trees together with the fact that the spraying was done with a gun from the ground. It is surprising that the same oil-Koloform combination produced no ill effects on Elberta trees.

TABLE 9. SUMMARIES OF INJURIES IN COMMERCIAL YORK IMPERIAL ORCHARD 1932

Drop fruit[2]

Treatment[1]	Number of fruit	Per cent cod. moth	Per cent curculio	Per cent leaf-roller	Per cent scab
Ortho K..............	3277	64.2	8.1	2.9	11.4
Ortho K Bordeaux.....	5684	42.9	7.7	1.5	8.4
Meedol................	4228	72.0	6.5	2.0	15.4
Meedol Bordeaux.....	4555	59.8	3.7	2.4	10.4
Koloform lead arsenate	2247	33.6	6.0	1.9	12.9

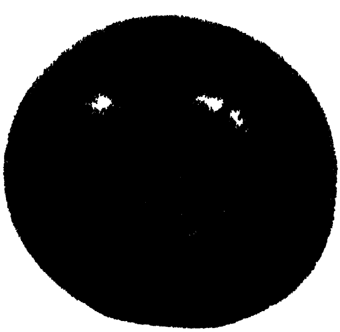
Picked fruit[2]

Treatment[1]	Number of fruit	Per cent cod. moth	Per cent scab	Per cent Russeted
Ortho K.........................	1528	29.4	17.6	8.4
Ortho K Bordeaux................	2007	32.1	9.5	7.4
Meedol..........................	1860	30.4	15.2	5.3
Meedol Bordeaux.................	2131	35.1	9.1	1.5
Koloform lead arsenate.............	2367	17.7	10.8	2.7

[1]For mixtures see Table 8.
[2]Percentages based on number of wormy or injured fruit not on number of injuries.

Considerable burning resulted from the application of one per cent Ortho K and one per cent Meedol in combination with twelve and a half

1



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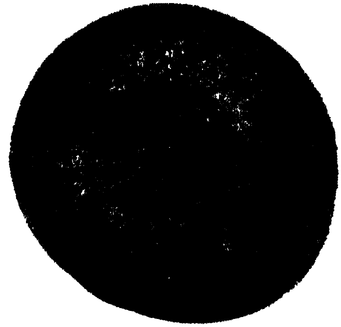

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1. Tree No. 31, a 7-year-old York Imperial which received 1 application of 3 per cent Engine oil and 3 applications of 1 per cent Texide in 1931 and 1 application of 2 per cent Ortho K in 1932. On November 1, 1932 the tree appeared to be in perfect condition. 2. A York Imperial showing Bordeaux oil residue. 3. Same apple shown in Figure 2 with Bordeaux oil residue removed, and revealing discolored areas on the surface of the fruit.

pounds of Koloform to one hundred gallons of water. The application was made on May 28 and injury was first noted on June 1. At this time the injury was slight but warranted the discontinuation of the combination. Later the injury became more noticeable. Bordeaux 3–3–50 was substituted for Koloform in the following two sprays and no further injury resulted. There was slight russeting of the fruit in all the blocks but it was more noticeable in the oil blocks. These blocks received an extra spray and heavier treatments than the lead-Koloform block. The Bordeaux-oil combination stuck to the fruit and was difficult to remove. Even when removed, light colored areas or spots could be seen on the surface of the fruit. The same type of spotting occurred in blocks where a lead-oil combination was used.

It was hoped that some reduction in codling moth infestation might follow the use of oils without arsenate of lead. The results were positively to the contrary. In the plots where Bordeaux-oil was used, there seemed to be a slight reduction in codling moth as is evident from the counts of the drop fruit. This, however, is of no practical importance. The percentage of scab was naturally reduced where Bordeaux-oil was used.

Applications of Oil Dusts in a Commercial Orchard.—A corner of a large Krummel orchard was divided into three blocks of fifty trees each. Plot I was dusted with No. 300 Niagara sulphur dust impregnated with 5% oil, Plot II with No. 302 Niagara sulphur, lead-lime dust impregnated with 5% oil and Plot III with an 80–20 sulphur-lime dust. All plots were treated six times as follows: May 20, June 21, July 14, Aug. 3, Sept. 2, and Sept. 15. About one pound of dust was applied per tree except plot III which was treated by the orchardist and received only about one-half pound of dust per tree. The drops that fell shortly before picking time were gathered from three trees in each plot and examined. The picked fruit from these same trees were examined and cut to determine the percentage of Oriental fruit moth injury.

Table 10. Summary of Oriental Fruit Moth Injuries on Krummel, O. C. Rice Orchard 1932

		Drop fruit				Picked fruit		
		Sept. 30		Oct. 3		Oct. 3		
Plot	Materials	No. fruit	% wormy	No. fruit	% wormy	No. fruit	% wormy	% cracked
I	Sulphur-oil dust No. 300 Niagara	462	86.4	46	80.4	2483	53.9	1.3
II	Sulphur-lead oil dust No. 302 Niagara	222	83.3	23	86.9	2471	30.7	5.4
III	Sulphur-lime dust....	473	83.0	46	84.7	2244	53.4	.4

Serious foliage injury appeared in plot II shortly after the application of sulphur-lead-oil dust on August 3. By picking time, there was considerable defoliation in this block. Injury was not evident where the sulphur-lime or sulphur-oil dusts were applied. The defoliation may have resulted from the application of too much material per tree.

All plots but more particularly plot II showed fruit injury. Cracks about one inch long appeared in the surface of the fruits but seldom extended as deep as the pit. This injury likewise may have resulted from heavy application of the materials.

The number of drop fruit gathered on September 30 is an indication of control. There were twice as many fruit down in plot I and III as there were in plot II. The picked fruit showed considerably less oriental fruit moth in plot II than in plots I and III.

DISPERSAL OF THE APPLE MAGGOT—1932 STUDIES

By C. R. Phipps, *Entomologist, Maine Agricultural Experiment Station*, and C. O Dirks, *Assistant Professor of Entomology, University of Maine*

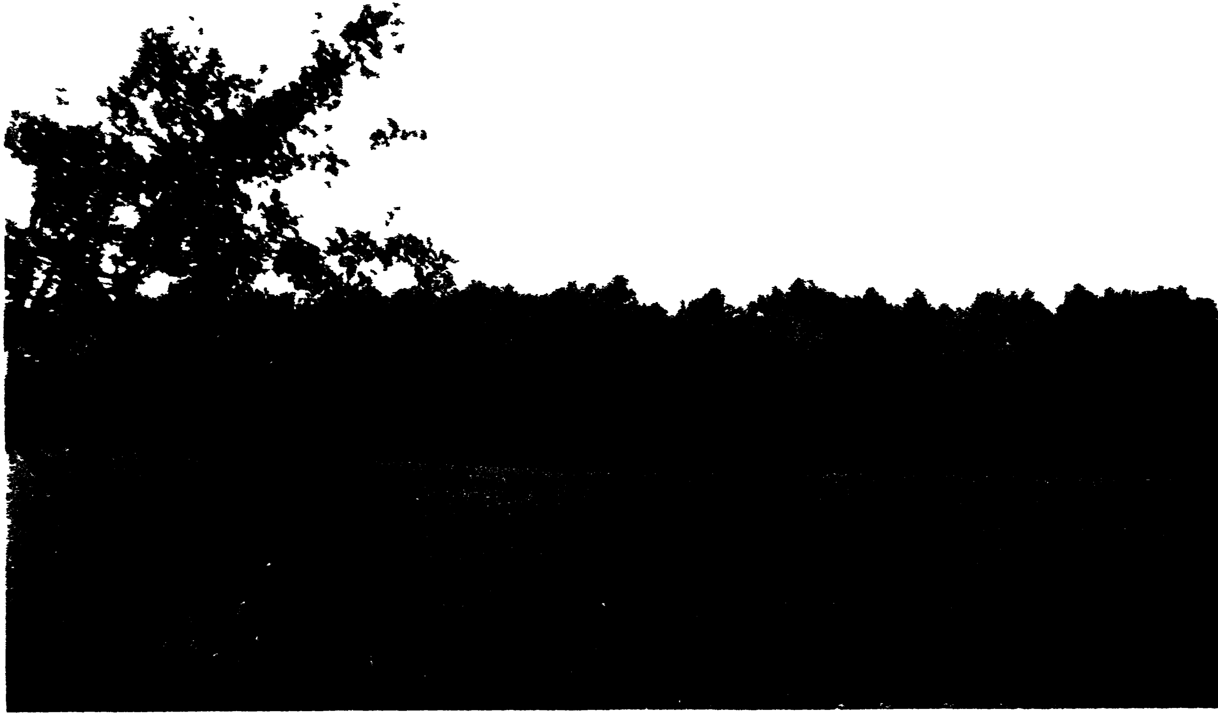
Abstract

This paper records the recovery of 130 marked apple maggot (*Rhagoletis pomonella* Walsh) flies out of a total of 3,152 which were released in one site. These marked flies were recovered at distances varying from 65 to 233 yards from the point of release. Although released in unsprayed trees bearing many apples, the marked flies soon left them as they did unsprayed non-bearing trees in similar experiments in 1931.

Marked flies released in young sprayed apple trees were not recovered.

In a previous paper by the authors[1] a successful method of marking apple maggot flies was described. Gold and aluminum radiator paint was the material employed. The paint comes in two parts, one consisting of a dry powder and the second of a liquid mixing reagent consisting chiefly of banana oil. This type of paint is available in many colors so that it is possible to distinguish different lots of flies released in the same place but under varying conditions. The enamel which is formed dries very quickly, adheres to the flies for a long period of time, and apparently does not injure them. It is applied by means of a camel's hair brush, a small spot being placed upon the thorax of each fly immediately after it is quieted by the use of ether or by exposure to low temperatures.

[1]Phipps, C. R. and Dirks, C. O. Dispersal of the apple maggot. Jour. Econ. Ent. 5:576-582. 1932.



One ot release trees in tor groun l n a ground tr ... s were r overed

In the experiments described in the preceding paper, 123 marked flies were recovered out of a total of 1,035 which had been released. These individuals were recovered by a careful and repeated search of the apple trees in the vicinity of the release area. The marked flies were captured by the use of glass vials, usually as they rested upon an apple fruit or leaf.

The trees in which the flies were released were not sprayed and neither were those upon which they were subsequently recaptured. The whole area was typical of village conditions since many varieties of apples were represented and none of the trees were sprayed or otherwise cared for. The seven apple trees which constituted the release point had previously been stripped of their fruit in order that the flies would have some incentive for dispersing

The recoveries were all made between July 17 and August 7 and on one day, August 5, 34 marked flies were taken. The 123 individuals which were recovered represented approximately 12 per cent of the total number released The distances which they had traveled varied from 38 to 156 yards and nearly 75 per cent dispersed 75 yards or more. Due to the large number of apple trees in the area selected and the wide range of varieties included, there was no particular reason, from the standpoint of food or oviposition, at least, for the flies to disperse more widely than they did

1932 Experiments. During the summer of 1932 a different release area was selected and one in which there were few apple trees near the release point. The same marking materials and methods were employed as in the preceding year although flies of known age were used in the tests. Three Baldwin apple trees situated near the center of a large field constituted the release point. Each of these trees bore a large crop of fruit which was left on it thus affording a different condition than that of the preceding season. Across an open field to the west and approximately 125 yards from the release point a dense woods (Plate 14) extends along one side of the area. Along the edge of this woods were scattered several seedling apple trees. A neglected unsprayed home orchard of 20 to 30 trees was situated about 130 yards away and to the north of the release point. In addition a number of scattered apple trees was distributed over the site (Fig. 27) to the south and east.

On July 25 one lot of 1,115 flies marked with green enamel was liberated in the Baldwin trees selected for this purpose. On July 27 a second lot of 1,367 flies marked with silver enamel was released in

the same trees making a total of 3,152 individuals in all. On August 1 the first marked fly was recovered and from that date until August 29

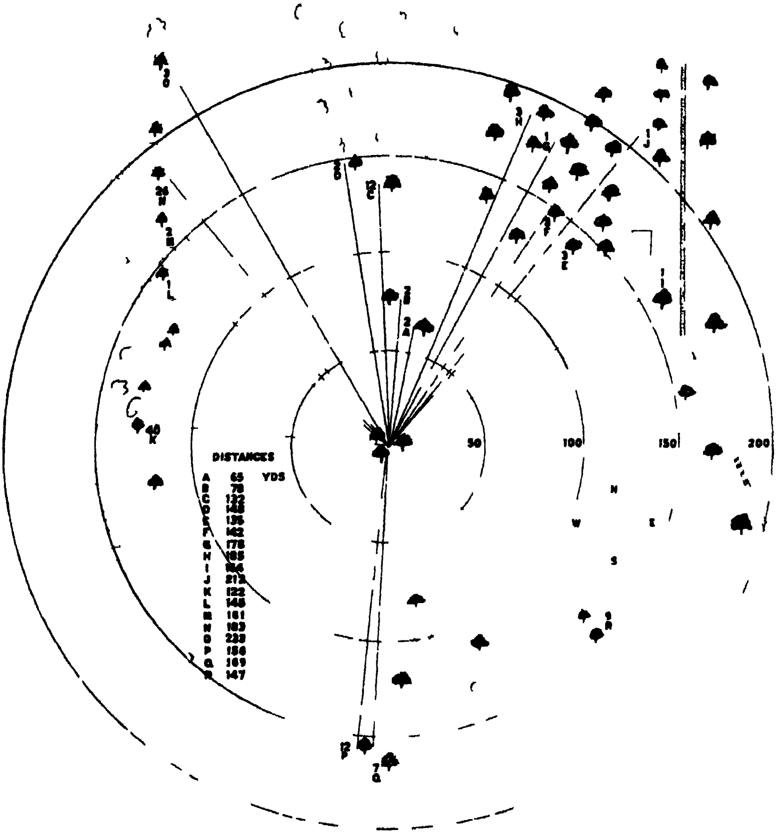


FIG. 27 —Diagram of release area showing release point in center. Each letter indicates a recovery tree and the accompanying number, the total number of marked flies recovered at that particular tree The distances from the release point to the various trees are given in yards

some were taken almost daily. Table 1 presents the number of flies recaptured at each tree, the distance traveled, and the variety of tree concerned.

In comparison with the experimental area under observation in 1931, this site was much more extensive and the number of trees to be searched was much greater. It was therefore natural to expect a smaller percentage of recovery than in 1931. A total of 130 flies was recovered during the course of the month's search as compared with 123 in the preceding season On a percentage basis, however, the recov-

TABLE 1. RECORD OF RECOVERY—DISTANCES FROM RELEASE POINT

Tree position and variety	Number of flies recovered	Distance from release point in yards	Tree position and variety	Number of flies recovered	Distance from release point in yards
A Baldwin	2	65	J Greening	1	212
B Baldwin	2	78	K Natural (seedling)	40	122
C Baldwin	12	132	L Natural (seedling)	1	145
D Baldwin	2	148	M Natural (seedling)	2	161
E Baldwin	3	135	N Natural (seedling)	26	183
F Alexander	3	142	O Natural (seedling)	3	233
G Greening	1	178	P Greening	12	156
H Baldwin	3	185	Q Baldwin........ .	7	169
I Fameuse	1	164	R Natural (seedling)	9	147
Total				130	

ery in 1932 represented slightly over four per cent of the number released as compared with nearly 12 per cent in the preceding test.

The marked individuals were secured at distances varying from 65 to 233 yards away. Seventy flies or nearly 54 per cent dispersed from 122 to 148 yards, 52 or 40 per cent traveled between 156 and 183 yards, and four flies or three per cent were recovered from 212 to 233 yards from the point of release. Table 2 presents a summary of the recovery data.

TABLE 2. SUMMARY OF RECOVERY RECORDS

Distance	Total No. recovered	Males	Females	Per cent of total flies
65 to 78 yards	4	3	1	3.1
122 to 148 yards.......	70	39	31	53.8
156 to 183 yards	52	30	22	40.0
212 to 233 yards	4	1	3	3.1

The sexes of the recovered individuals were fairly evenly divided, 56 per cent being males and 44 per cent females. This is in contrast with the 1931 experiment in which a relatively small per cent of females was recovered. Table 3 summarizes the age of the recovered flies at the time of recovery. It seems unlikely that many are injured in the process of marking since over 25 per cent of those taken were from four to five weeks old.

TABLE 3. RECORD OF AGE OF FLIES WHEN RECOVERED

Age in days	Number of flies	Per cent of total
7 to 10 days..	14	10.8
11 to 15 days..	28	21.5
16 to 20 days..	50	38.4
21 to 25 days..	5	3.8
26 to 30 days..	16	12.3
31 to 37 days..	17	13.1

The first female observed mating was 15 days old and the last one 35 days old. One of the last females recovered was over five weeks old. She was taken on August 29 after being observed ovipositing.

During the past season we likewise released a large number of marked flies in various parts of a young sprayed orchard on the Maine Agricultural Experiment Station farm in Monmouth. Although these lots were released at different times and situations and were marked in the same manner as those used in the preceding experiment, not a single one was subsequently recaptured. It would have been much easier to have found and recovered these flies since the trees were much smaller than those in the site previously discussed. Therefore, although some of the flies were probably poisoned, other factors must have been concerned with their disappearance. The sites selected were fairly open and the trees were just coming into bearing, so that either lack of adequate shelter or scarcity of fruit may have caused them to disperse widely.

Conclusions. Flies released in trees bearing fruit may disperse a considerable distance to trees of the same or different varieties.

This season's results would indicate that dispersal need not be a gradual process, as suggested by the 1931 experiments. In fact many of the marked flies traveled across open fields to apple trees approximately 125 yards away.

As in the preceding year's work, the recoveries were made on trees located in practically every direction from the release point. This would indicate that over a period of several weeks the flies tend to disperse rather widely.

The distances traveled were somewhat greater on an average than those recorded in the 1931 study. However, only 3 per cent of the total recovery was made at points more than 200 yards from the release trees. Therefore, there appears to be no reason for altering the recommendation that the removal of all neglected apple and wild haw trees within 200 yards of commercial plantings will largely prevent infestation from without the orchard.

Mr. Oscar H. Hammer: I was wondering if Mr. Dirks noted any correlation between the prevailing wind direction and the distribution.

Mr. Dirks: It would be pretty hard to get any data on that point since the time spent in looking for the flies was over a considerable length of time. It extended this year over a period of a month. During that time they would have a chance to disperse in all directions. Of course, the wind varied a great deal during that time.

MR. MAX KISLIUK: I was wondering if nets could not be used to more advantage than the vial in getting these marked flies. My experience has been that you would miss a good many if you tried to get the vial over them, whereas with a net as soon as you can see them, if you are quick with your hands, you can catch a fly.

In my experience in collecting in foreign countries, I gave up the vial method long ago and used the net because we no sooner saw the fly than we caught it. With a vial you have to creep up to it and there are a good many chances where you lose it.

NOTES ON THE BIOLOGY OF THE APPLE MAGGOT

By C. R. PHIPPS, *Entomologist, Maine Agricultural Experiment Station*, and C. O. DIRKS, *Assistant Professor of Entomology, University of Maine*

ABSTRACT

This paper deals with the life history of *Rhagoletis pomonella* Walsh in Maine. It presents data which indicate that time of fly emergence is governed by a number of factors. Some of these factors are: variety of fruit in which the larva develops; nature of the soil (light or heavy); location; and amount of rainfall during the emergence period.

In order to obtain large quantities of the larvae for various purposes a special trap was developed.

A small fall or second brood of flies has been produced in our cages each year in one section of the State but not in others where the soil is heavier. Only larvae which develop in early or summer varieties transform to flies the same season. Practically all the second generation flies appear during the first two weeks in October—hence they are not of economic importance.

Two-year cycle flies are likewise recorded.

Counts covering the daily sex records of nearly 23,000 flies in 1932, indicate that the period during which the males and females emerge in nearly equal numbers coincides with the peak of emergence.

In many eastern apple growing districts the apple maggot (*Rhagoletis pomonella* Walsh) is at present the most injurious insect pest attacking the apple. The export situation with special reference to this insect and also the evident influence of the neglected apple tree have recently served to focus the attention of many fruit growers and investigators upon its activities.

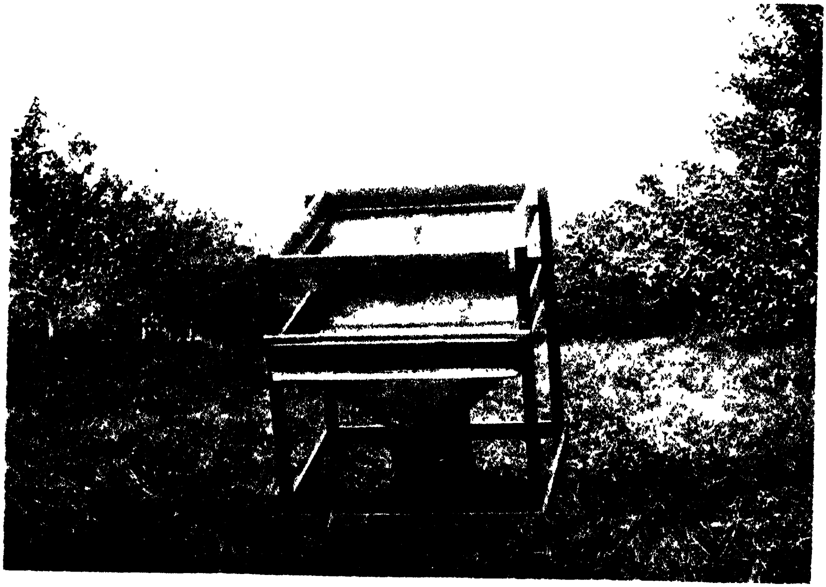
Reports from investigators in these districts indicate that in 1932 an unusually large proportion of late apples was attacked. It is probable that the delayed emergence of the flies may have accounted for this condition in part, although many growers feel that the insect was actually much more abundant than in 1931. Some idea of the

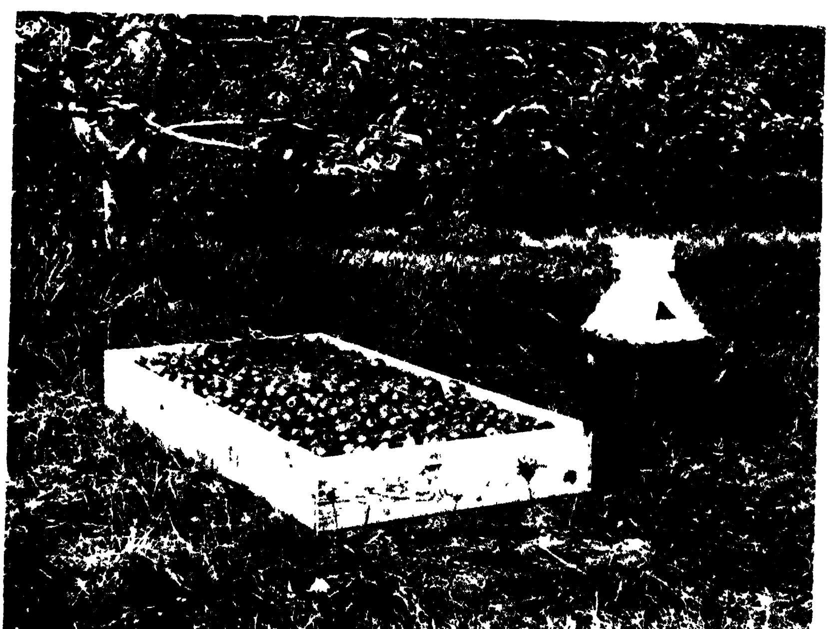
importance of this pest in comparison with other destructive agents may be gained from the following table which presents the results of the Maine 90 Per Cent Clean Apple Club inspections in 1932. On the basis of the 30 orchards which passed the inspection, the apple maggot ranked first among all disease and insect pests recorded. In the case of those orchards which applied for the inspection and failed to pass, the influence of this insect was usually much more pronounced.

TABLE 1. 90% CLEAN APPLE CLUB—MAINE—1932 30,000 APPLES

Pest	Occurrence	% of total
Apple Maggot	366	18.33
Codling Moth	312	15.62
Apple Seed Chalcid	304	15.22
Apple Scab	277	13.87
Bud Moth	175	8.76
Plum Curculio	162	8.11
Leaf Roller	121	6.06
Fruit Worms	98	4.91
Apple Curculio	91	4.55
Sooty Fungus	43	2.15
Oyster Shell Scale	24	1.20
Rosy Aphid	13	.65
Juniper Rust	6	.30
Lesser Apple Worm	5	.25
	1,997	

APPARATUS USED IN LIFE HISTORY WORK. By means of concentrating traps (Plate 15) and emergence cages located in different parts of Maine various phases of the insect's life cycle are being investigated. The concentrating traps consist of two heavy screen wire racks, each about 40 inches square, which are spaced one above the other in a wooden frame supported on four legs about four feet in length. Boards about eight inches high extend around each rack in order to hold the supply of infested fruit. The use of two racks instead of one doubles the quantity of fruit which can be handled in each trap. From the bottom of the lower rack a funnel-shaped cloth sleeve leads down to a wooden box containing a removable tray. This box which rests upon the ground is about 12 inches square and 18 inches in height. Badly infested apples of the desired variety are collected at the proper time and placed on the racks. As the maggots become full grown they leave the fruit and drop down thru the wire screen and the cloth cone into the removable tray beneath. The larvae are counted two or three times a day, and then transferred to bottomless overwintering boxes (Plate 16) which are buried in the ground. These boxes are approximately 16 inches long, 12 inches wide, and 10 inches deep. Prior to the time of emergence small screen-covered cages are placed upon





Above. Double-decker type of trap used in life history studies. Below. Ground trap and emergence cage.

Plate 16

Battery o[illegible]

the overwintering boxes so that the flies will be caught as they emerge from the soil. These cages are darkened by means of black cloth so that the flies collect in small removable screen wire boxes which fit onto the top of the cages.

This double-decker trap provides an accurate means of counting the maggots as they emerge from a known variety and number of fruits. Thus, fairly exact figures may be obtained upon the production of larvae per apple, upon the influence of various factors concerned with larval survival, upon the per cent of one-year cycle, two-year cycle, and second generation flies in comparison with the number of larvae originally used in the test, etc Moreover, by using small overwintering boxes and correspondingly small emergence cages, the emerging flies may be collected in a relatively short time each day. On the other hand, a more natural method of handling the apples would be to spread them on large screen racks (Plate 15, below) supported a few inches above the ground. The larvae as they matured could then leave the fruit and drop to the ground without being handled

COMPARISON OF DIFFERENT TYPES OF APPARATUS It would be logical to expect that in the process of counting some of the larvae might be injured. This would mean that survival and other records based upon these counts would be inaccurate Moreover, the concentration of thousands of larvae in the relatively small overwintering boxes might be thought to cause a heavier mortality than would otherwise occur. In order to obtain some information upon these points it seemed desirable to run a survival test using both types of apparatus. Consequently a very heavily infested lot of Wealthy apples was collected from four unsprayed trees for test purposes. These apples were divided into two reasonably uniform samples. The first lot of 2,170 apples was placed in a double-decker trap, the larvae being counted each day and then transferred to an overwintering box. The second lot of 2,060 apples was placed on a large ground tray and the larvae in this set-up were permitted to go directly from the fruit into the ground without being handled. The following table presents the results of this experiment.

TABLE 2. COMPARISON OF APPARATUS USED IN LIFE HISTORY STUDIES

Apparatus	Variety	Number apples	Number larvae	Number flies	% survival
Trap-tray in...	Wealthy	2,170	10,163	4,084	40.1
Ground trap	Wealthy	2,060	9,640*	3,150	32.6

*Calculated.

That the per cent of survival or fly output was higher in the case of the small trap in which the maggots were actually handled may

seem surprising. Probably this difference was due in part, at least, to the fact that in capturing the flies in the large ground cage each day, the collector packed the ground and thus prevented the emergence of some of them. Then, too, some of the newly emerged flies, while relatively inactive, may have been crushed by the collector. At any rate, considering the additional information afforded in connection with the smaller trap, and likewise the saving in time and materials incidental to its use, there would appear on the basis of one season's data to be no reason for abandoning it in favor of the other type of set-up.

LARVAL PRODUCTION AS INFLUENCED BY VARIETY AND LOCATION. In general, the variety of apple is the most important factor in the production of mature larvae, the early ripening sweet or sub-acid sorts producing by far the largest numbers. Table 3 shows this influence in a test which included early, fall, and late varieties.

TABLE 3. LARVAL PRODUCTION BY VARIETY

Variety	Number of apples	Number of larvae	Larvae per 100 apples
Golden Sweet	1,206	7,644	633
Williams	423	2,676	632
Rolfe	421	2,288	543
Wealthy	2,170	10,163	468
Fameuse	976	4,428	453
Red Astrachan	1,950	6,957	356
McIntosh	121	199	164
Baldwin	1,000	246	24.6

The foregoing table shows that an early susceptible variety such as Golden Sweet may produce an average of nearly seven maggots per apple whereas a late variety such as Baldwin may produce less than three-tenths of an individual per apple.

In different localities the same variety of fruit may show a material difference in larval production. Thus, Table 4 shows that in Cumberland Center unsprayed Golden Sweet trees produced an average of nearly 12 maggots per apple, while the same variety collected on unsprayed trees in Monmouth produced only 6.3 individuals per apple. This difference is no doubt explained by variation in the fly population in the two places as well as possible differences in the supply of attractive apples.

LARVAL MORTALITY AS INFLUENCED BY LOCATION, VARIETY AND SOIL TYPE. Larval mortality will vary greatly with the particular locality due to possible variation in the abundance of parasites, predatory enemies, and other factors. Upon the basis of one season's work (Table 4) the larvae from certain varieties of apples in Monmouth

showed a consistently lower per cent mortality as compared with others from the same varieties in Cumberland Center.

TABLE 4. INFLUENCE OF LOCATION AND VARIETY ON THE PRODUCTION OF LARVAE AND FLIES

Variety	Location	Number larvae	Number per apple	% flies
Golden Sweet	Monmouth	7,644	6.33	39.7
Golden Sweet	Cumberland Center	10,956	11.87	22.1*
Red Astrachan	Monmouth	6,957	3.56	28.9
Red Astrachan	Cumberland Center	5,471	2.78	26.5*
Williams	Monmouth	2,676	6.32	26.1
Williams	Cumberland Center	11,121	11.46	23.19*
Wealthy	Monmouth	10,163	4.68	40.1
Wealthy	Cumberland Center	3,804	3.00	27.2

*Including second generation flies.

Larvae from early susceptible varieties may exhibit a higher per cent of mortality than those from late varieties although the total production of larvae is, of course, much greater in the early fruits. In summarizing the data for 1932, as shown in Table 5, such a difference in mortality is indicated.

TABLE 5. INFLUENCE OF APPLE VARIETY UPON LARVAL SURVIVAL

	Number apples	Number larvae	Number flies	% survival
Early varieties	3,579	17,277	5,650	31.5
Fall varieties	5,316	24,754	9,203	35.5
Winter varieties	3,025*	239	98	41.5
Totals	11,910	42,270	14,951	35.3

*Some apples stolen.

Early apples tend to break down or decay as a result of the larval trails in the fruit and it is possible that some of the maggots are adversely affected by this condition. Also it is possible that parasites may be more active in parasitizing larvae in early soft fruit than in late hard varieties.

Other investigators have reported that larval mortality is much higher in a wet heavy soil than in a light dry soil. Table 6 presents figures covering a test involving approximately 20,000 larvae under the two conditions.

TABLE 6. INFLUENCE OF SOIL UPON SURVIVAL

Soil	Variety	Number larvae	Number flies	% survival
Heavy loam	Wealthy	9,821	1,320	13.4
Light loam	Wealthy	10,163	4,084	40.1

The table indicates a difference of over 26 per cent in the survival of the larvae which overwintered in relatively light dry loam.

FLY EMERGENCE. The time of fly emergence is influenced by the variety of apple in which the larva develops. As an example, in 1931 and again in 1932 the flies from Red Astrachan and other early fruits in Cumberland Center began to emerge about a week sooner than those from McIntosh and all later sorts. Porter (1928, p. 45) reports similar results in Connecticut but certain other investigators have indicated that there is no appreciable difference

Time of emergence is also affected by moisture and temperature relationships which vary from season to season. This is illustrated by an examination of Fig 28 which charts the emergence of over 30,000 flies in two localities during the past two summers A study of these graphs shows that emergence began in the earlier locality on June 19 in 1931 and in the later locality on July 3 In 1932 the flies began to emerge in these two sections on approximately the same dates as in 1931. However, in 1931 the peak occurred on June 30 in the earlier location and on July 15 in the later site In 1932 the peak was not attained until about two weeks later in each section This condition was probably due to the unusually dry weather which prevailed in mid-summer and caused the ground to become dry and hard Ordinarily the insect is much more destructive during seasons of late emergence since the flies are then present until late in the fall As a result, they infest many valuable late apples normally free from attack

The nature of the soil in which the pupae overwinter is an important factor with reference to time of emergence This factor constitutes one of the principal differences between the two localities referred to in Fig. 28, for they are less than 40 miles apart. There has been a consistent emergence difference of about two weeks in these locations, the soil being much lighter and drier where the flies appear first. In general, emergence is over in Maine by the middle of August. In 1932 in counts involving over 20,000 flies in Monmouth there was a straggling emergence thruout September and one individual appeared as late as November 1st

SEX RATIO VS. PEAK OF EMERGENCE. Our records indicate that the majority of the early emerging flies are females whereas most of the late emerging individuals are males. As the season advances the proportion of females to males gradually decreases. On the basis of counts covering sex records of 7,510 flies in Cumberland Center and 15,240 flies in Monmouth, in 1932, it was found that the period during which the sexes were about evenly divided as to numbers (Fig. 29) coincided with the peak of emergence. If the correlation between the equality of the sexes and the height of emergence is supported by

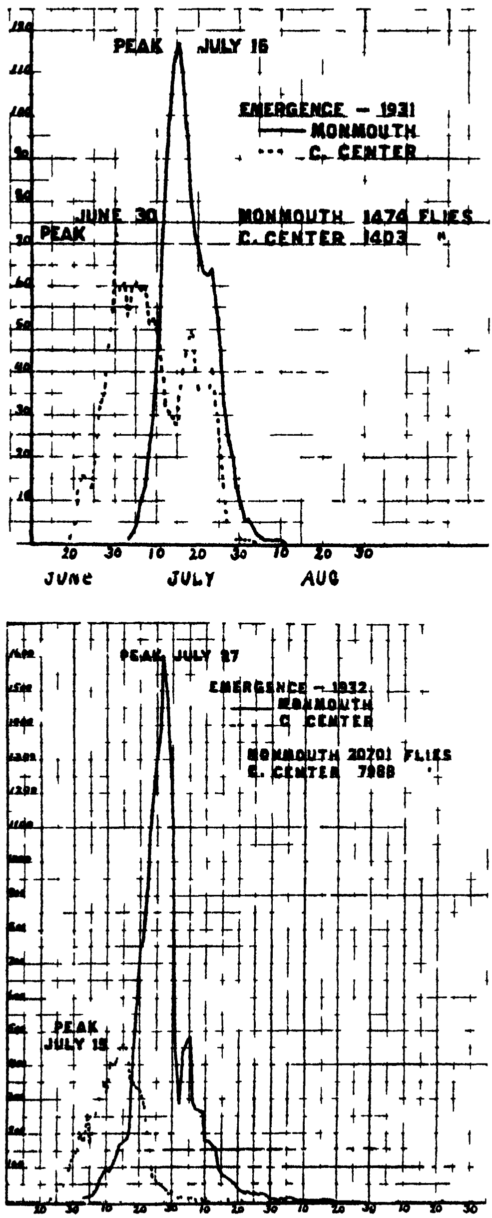


FIG 28.—Emergence of flies in Cumberland Center and Monmouth in 1931 (above) and 1932 (below)

further investigations, it may be possible to recognize the height of emergence before it has definitely passed—an important feature from the standpoint of control by spraying.

Second Generation Flies During the last three years the presence of a second generation of flies has been observed in our cages in one

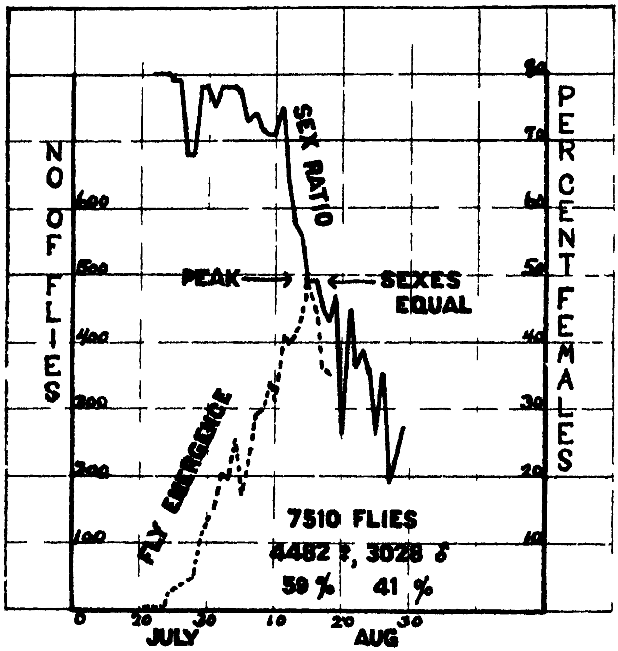


Fig. 29 - -Relation of sex ratio to peak of emergence in 1932

location in Maine In 1931 there were 155 second generation flies (Fig. 30) collected in our cages in Cumberland Center during October. This number transformed from 27,548 larvae which had developed from three lots of early apples. Of this number, 111 developed in Golden Sweet apples, 34 in Red Astrachans, and 10 in Williams Upon a percentage basis the foregoing flies represent an emergence of 1 per cent, 0.6 per cent, and 0.08 per cent, respectively, of the total number of larvae employed in each test.

In 1932 there were but four second generation flies produced in a less extensive test involving 4,846 larvae from Red Astrachan apples. These adults also appeared in October.

The production of second generation flies has been reported by Caesar and Ross (1919, p. 23) in southern Ontario, by Porter (1928, p. 45) in Connecticut, and by certain other investigators. On the

other hand, the writers have failed to obtain any second brood flies at Monmouth although larvae from the same varieties from which fall brood flies appeared in Cumberland Center, have been under observation in Monmouth during the past three years. Likewise O'Kane

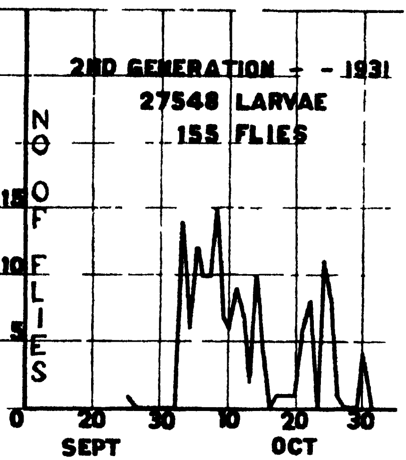


FIG. 30 – –Second generation fly emergence in Cumberland Center in 1931.

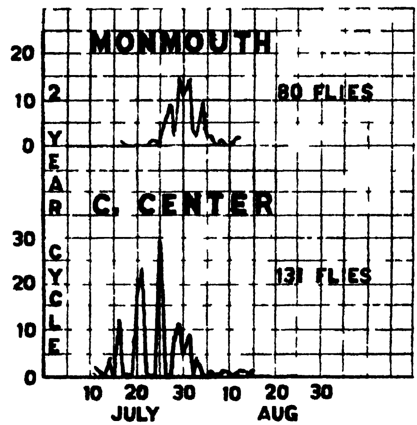


FIG 31.– Emergence of two-year cycle flies in Cumberland Center and Monmouth 1932,

(1914, p 41) reported no second generation individuals during the course of extensive experiments in New Hampshire

It seems probable that the soil temperature in the fall plays an important part in the occurrence of second generation flies. At any rate the soil in Cumberland Center is much lighter and drier, and consequently warmer, than the soil in the other location where the flies did not appear. In view of the fact that these fall brood flies do not emerge until so late in the season, and therefore are not able to oviposit in the fruit until most varieties are harvested, their economic significance is slight.

TWO-YEAR CYCLE Several investigators have reported the fact that a part of the larvae spend two winters in the ground instead of one. The flies which emerge during the second summer are known as two-year cycle individuals. Cages established in Cumberland Center in 1930 yielded 131 two-year cycle flies in 1932. This number represented 8.5 per cent of the total number of flies which had previously appeared as one-year cycle adults. At Monmouth 80 two-year cycle flies appeared in the cages. This number represented 5.2 per cent of the total prior emergence. In both locations the two-year flies appeared at the height of the regular one-year emergence period (Fig. 31). Thus, no control complications arise.

It is possible that some of the flies may spend three winters or longer in the pupal stage as recorded by Lathrop and Nickels (1932, p. 19) in the case of the blueberry maggot.

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THE CODLING MOTH IN NEW YORK

By P J PARROTT, *Geneva, N. Y.*

ABSTRACT

The importance of the codling moth (*Carpocapsa pomonella* Linné) to the apple industry of New York and the status of spray practices are briefly summarized.

The apple grower in New York has to contend with an exceptionally large number of important pests. While some are of greater significance than others, yet by and large, none of them under average conditions, with the possible exception of apple scab, present the serious aspects characteristic of some of these pests in other areas The horticultural history of the state shows that exceptional injury by the common pests usually runs in cycles, and while the codling moth is indisputably the major insect, nevertheless one or several of a number of species may rank greater in importance during a given period in the estimation of growers. The multiplicity of highly injurious species, therefore, makes the question of compatibility of different spray materials adapted to the control of the various pests of great significance. The problem of devising a standard spray program capable of meeting the more important needs to a reasonable degree of satisfaction presents many difficulties. Considering the present point of view of many growers, added complications are spray residue and the standards of the port inspection service of foreign lands relative to tolerance for insect injury.

These considerations, it is hoped, make clear that if there are aspects of general interest with respect to the efforts with the codling moth these will center more about the broad program of pest control rather than in specific undertakings against the insect itself.

INFLUENCE OF VARIOUS FACTORS ON SPRAY PRACTICES.—In addition to exceptional difficulties with the codling moth, the past three years have been a trying period for many apple growers for reasons that are not difficult to understand. During the unprecedented outbreak of the codling moth prices for fruit have been low and orcharding, like all other lines of agriculture, has been influenced greatly by the economic stringency. Lean times like these have necessitated careful scrutiny of cash outlays since the margin of profit is small. As a consequence, expenditures for spray material and labor have been governed to a surprising extent by the financial resources of the grower rather than by the needs of his plantings for protection from pests. In many sections there were not a few growers who made no attempts to follow orthodox spray practices and who, if they sprayed at all, exercised their own judgment with respect to selection of spray materials and periods of application. These were highly speculative procedures and, as one would expect, large losses were sustained in individual instances; and the task during future years of securing efficient control of the codling moth, as well as other pests, has doubtless been rendered more difficult.

Then, again, the course of events during recent years has changed so rapidly that it has been difficult for many growers to keep pace with new developments. Engulfed as he is in the economic whirlpool, the state of mind and orchard practices of the average grower are far too often out of accord with the demand of the times; hence many of the difficulties encountered with the codling moth and the unsatisfactory situation with spray residues, particularly with reference to the control of the apple maggot, the bud moth, and the second generation of the codling moth.

Few, so far, wash or brush their fruit, and to reduce their chances of encountering difficulties with spray residue there is a tendency to omit the midsummer treatments so essential for the adequate control of the foregoing pests. Generally speaking, then, the orchard industry in New York stands confronted with two horns of a dilemma. If all important treatments in the spray schedule are made, difficulties may arise with excessive spray residues. On the other hand, if essential treatments are omitted, the greater the danger from inroads by various pests.

In those sections where there is an acute need of a satisfactory solution of these perplexing questions there is a tendency among leading growers to choose the former alternative—to spray as circumstances demand and if necessary subject the fruit to a cleaning process. If experience justifies this course of action, brushing, wiping, or washing

apples will doubtless be favorably regarded by an increasing number of growers during succeeding years.

In view of the foregoing difficulties which beset the apple industry and considering the adoption of brushing and washing of fruit by competing orchardists, no one step in the light of present knowledge would make for greater progress or do more to stabilize spray practices in this state than a more general adoption of cleaning methods. In surveying events during recent years it may truly be said that the onslaught of the codling moth and attendant injuries by apple maggot have impressed on the minds of many growers that the general improvement of spray practices and associated activities stand in the forefront of the interest of the orchard industry.

Importance of the Codling Moth During Recent Years.—During the past three years the codling moth has taken an exceptionally large toll from many apple orchards in western New York. In neglected and poorly sprayed orchards, stings, together with side and end injuries, affected as high as 50 to 80 per cent or more of the fruit. Plantings that were well or fairly well sprayed ran on an average of 20 to 40 per cent for worm holes and stings, mostly the latter. The majority of orchards operated on a high plane of efficiency and regarded as the prize plantings in their respective communities displayed varying degrees of injury well below the foregoing minimum. Where spraying according to high standards was supplemented by such practices as breaking of clusters and thinning of crop for undersized and defective fruits infestation was, generally speaking, of negligible importance. Even where thinning was omitted, the crops in certain orchards displayed damage not to exceed 5 to 10 per cent for stings and worm-holes. Considering the more propressive growers from all areas of the state as a group, only a few experienced much difficulty in holding damage by the pest to a satisfactory level.

In the entire Lake Champlain area no great concern has been expressed relative to the activities of the codling moth. With respect to the Hudson River valley, stings were generally noted as being somewhat more abundant than usual. However, with the exception of a few growers in one important apple district no apprehension exists with reference to the insect. The chief source of complaint is the apple district extending from the Niagara river to Rochester. In 1931, due to a long growing season that was moderately dry with temperatures considerably above normal, a large second generation developed which greatly accentuated the injury inflicted by the first generation In many orchards the dam-

age to the apple crop was very high. Conditions would not have been so bad had growers followed the schedule of treatments which conditions demanded. However, to avoid spray burn and excessive spray residue, as well as to curtail expenses, many plantings, particularly old apple orchards, either were not sprayed at all or were poorly sprayed. Where these practices prevailed the codling moth has had pretty much its own way. Because of the prevalence of wormy fruit, the spectacle was indeed an impressive exhibition of the destructive capacity of the insect. Similar conditions prevailed during 1932, altho, on the whole, conditions with respect to the codling moth were not quite so critical as during 1931.

Efficiency of Control Measures.—With respect to control of the codling moth, it has been regarded as a moderately serious pest which could be readily combated. Its importance and susceptibility to treatment are indicated in Table 1 which summarizes the data obtained during the past twelve years from tests in our Rome orchard in which the counts each year ran from 111,200 apples as a minimum to 209,739 as a maximum.

Table 1. Codling Moth Injury on Sprayed and Unsprayed Romes, 1920–1931

Year	Per cent insect injury Sprayed	Unsprayed	Relative size of crop
1920	0.75	10.00	Large
1921	10.77	26.00	Small
1922	1.89	33.91	Medium
1923	4.67	26.14	Small
1924	2.25	20.42	Large
1925	7.48	25.62	Medium
1926	3.73	38.00	Medium
1927	3.79	30.62	Large
1928	3.32	48.33	Small
1929	3.36	20.21	Large
1930	3.08	53.28	Medium
1931	22.67	80.00	Small

Progressive growers who have systematically applied two cover sprays for the first generation and one cover spray for the second generation usually obtained a high degree of control. The actual results varied more or less from the figures given according to the standards of farm management of individual growers, locality of orchard, and sanitary condition of the planting preceding and during years of intensive injury, etc. The average fruit grower is generally satisfied with a lower standard of efficiency and from certain localities during some seasons complaints come occasionally from this type of orchardist relative to the prevalence of injury and difficulties experienced to secure satisfactory control. The inability of some of our growers to hold the pest to a low

level has not generally been a matter of great concern to the Spray Service, since the failures have been regarded for the most part as anomalies which could be corrected by a better adjustment of the spray program to the conditions that exist in a given orchard or locality. However, the experiences during the past three years have not only made clear that the pest may be more formidable under our conditions than has generally been held, but they also point out the desirability of a very careful consideration of spray practices to determine if current recommendations really meet the needs of the present emergency. A study of Table 1 indicates that for a period of ten years or more the average amount of injury from the codling moth in the sprayed plats was approximately 4 per cent and that during 1931 the damage amounted to about 23 per cent, consisting mostly of "stings." Since varying proportions of injury of this character are permissible according to the grade of pack, the actual financial losses from such defects have not been large. Nevertheless, such developments with respect to the pest are significant and obviously the study of the insect is one of our major problems.

During the past summer an extensive series of experiments were conducted in the heart of the area displaying heavy infestation. The tests included treatments to determine the value of each cover spray, additional applications, arsenical substitutes, increased dosages, various spreaders, and summer oils. Efforts were also made to ascertain the usefulness of certain orchard practices, such as pruning and thinning, on the rate of infestation. The data presented in Table 2 show the

TABLE 2. EFFECTIVENESS OF DIFFERENT SPRAY MATERIALS ON THE CODLING MOTH DURING 1932

Treatment	Cover sprays applied	Per cent codling moth injury: Stings	Wormy fruit	Total
Dry mix—lead arsenate	1, 2, 3	16.7	4.2	20.9
Dry mix—lead arsenate	1, 2, 3, 4	9.8	1.4	11.2
Dry mix—lead arsenate	1, 2, 3, 4, 5	8.1	0.4	8.5
Lead arsenate—fish oil Lead arsenate	1, 2, 3 4	5.3	0.6	5.9
Lead arsenate Lead arsenate—oil	1, 3, 4 2	6.2	0.5	6.7
Lead arsenate Lead arsenate—oil	1, 4 2, 3	4.1	0.4	4.5
Lead arsenate Lead arsenate—oil Nicotine—oil	1 2, 3 4	6.4	0.6	7.0
Barium fluosilicate—oil	1,2,3,4	5.5	6.1	11.6
Check—no cover sprays		6.4	61.7	68.1

average efficiency of several materials selected from a rather large list of insecticides and they serve primarily to indicate the degree of control of the pest that can be secured under our conditions.

It cannot fail to be of profound significance that with the heaviest infestation experienced in thirty-five years most of the spray mixtures displayed an efficiency varying from 90 to 95 per cent. Owing to the surprisingly small differences in effectiveness, it can hardly be said with any degree of confidence that one spray material is really more effective than another. With respect to the merits of mixtures adapted to conditions in our general area, the selection must obviously be submitted to the test of agreement with observation and experience, and practicability determines the choice. Considering efficiency, safety, cost, and compatibility of spray constituents, the foregoing tests suggest no better combination than arsenate of lead with lime-sulfur or one of the milder sulfur fungicides, such as dry-mix, according to the season's indications with respect to scab development. To reduce the risk of spray burn, we prefer to use as much as possible one of the substitutes for lime-sulfur, subject of course to the advice of the plant pathologists. Considering the complexities of our situation, the prevailing system of treatment as recommended by the Spray Service is the best that can be formulated; but it must be admitted that there is need of a better way, tho as yet we have no intimation what it is.

It will be noted that the reputation of oil and lead is sustained and perhaps it may find a place in our spray program, particularly in emergency cases. But here, as well as under average conditions, its compatibility with other spray materials, especially those used in disease prevention, will require careful consideration.

With the means of control clearly outlined, apparently what the orchard industry of New York needs most just now is a decisive change in the economic position of growers which will make it possible to place spraying on a higher plane and to adopt more generally those supplementary practices concerned particularly with the improvement of the external appearance of the fruit preparatory to marketing.

CHEMICALLY TREATED BANDS

By M. D. FARRAR and W. P. FLINT, *Urbana, Ill.*

ABSTRACT

In Illinois over a five year period the cold dipped, corrugated paper band (Powdered beta naphthol —1 lb., 200-300 seconds viscosity oil—1½ pints, gasoline—1 pint) has been as effective in stopping codling moth (*Carpocapsa pomonella*) emergence as the hot dipped band. The cold band has advantages as to uniformity of deposit, fire hazard and ease of preparation. New cold dipped formulae of high efficiency are given.

The use of bands for the collection of codling moth larvae as a means of reducing the codling moth population in an orchard has been known and practiced for more than 100 years. Their use has been recommended by horticulturists and entomologists, particularly in years when codling moth have been abundant.

Forbes (1885, 3) mentions banding with rags or similar material as a standard practice for codling moth control. Flint (1917, 1) in testing the various types of paper for bands, found that a tar paper band caught about twice as many larvae as did light brown building paper, blue building paper, or burlap bands. Glenn (1917, 4) demonstrated the effective use of a block trap in connection with a tanglefoot band, as a means of reducing the labor costs of orchard banding. Flint and Goff (1929, 2) present additional data on types of paper suitable for bands, both untreated and treated with chemicals. The results of their work indicated that a cold treated beta naphthol band could be used as effectively as the hot treated band recommended by Seigler, et al. (1927, 5, 6).

There is no question but what the corrugated paper coated with a mixture of beta naphthol and oil in the ratio of 1 lb. to 1½ pints is a very effective band in killing codling moth larvae. This type of hot band has failed in many cases largely because the deposit of chemicals was not uniform throughout a series of bands. The reason for the wide variation in deposit is illustrated in Figure 32. There is a direct relationship between the amount of material deposited and the temperature at which the bands are dipped. A mixture too cold will clog the corrugations while one too hot will leave but little chemical in the band. Tests with the over-heated bands demonstrate that they will not give an effective control of larvae under field conditions. With properly regulated dipping temperatures it is possible to produce a fairly uniform hot treated band. Under conditions such as used by the orchardist in making hot bands it is impossible to regulate temperatures closely. Consequently the bands have varied widely in their efficiency.

The cold treated bands have several advantages over the hot method:
(1) A very uniform coating is obtained.
(2) Fire hazard is practically eliminated.
(3) Bands can be treated by inexperienced laborers.
(4) Dipping equipment is simple and available.

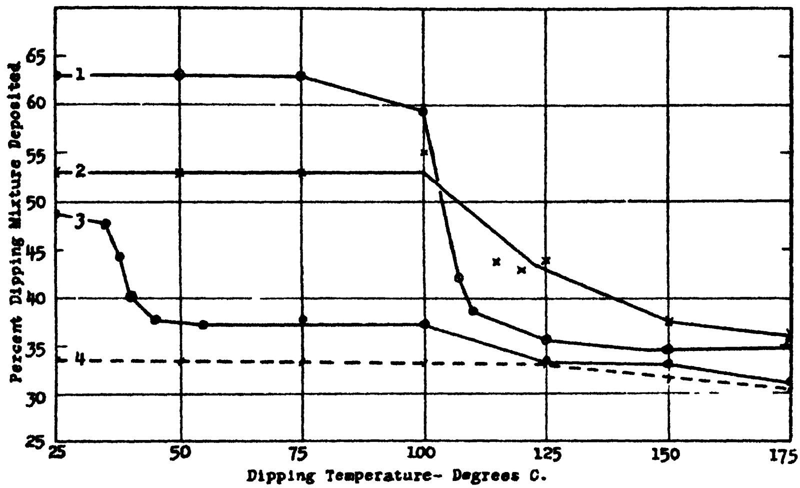

FIG. 32—Relation between the temperature of a dipping mixture and the per cent of material deposited on a corrugated paper band four inches in width. 1—Beta naphtholamine (M. P. 111° C.); 2—Beta naphthol (M. P. 124° C.); 3—Alpha naphtholamine (M. P. 43° C.) plus "Parawax"; 4—Diamond Paraffine oil (104 seconds Saybolt 100° F. Paraffine base straw oil). Numbers 1, 2, and 3 with oil in a ratio of 1 pound to 1.5 pints of oil.

The results over a five year period have demonstrated that the cold band is as efficient in the killing of codling moth larvae as is the hot treated band. Table 1 summarizes the results obtained in Illinois with the two types of bands. The differences in numbers of larvae taken per band are not significant for these treatments.

TABLE 1. SUMMARY OF FIVE YEARS EXPERIMENTS TESTING THE EFFICIENCY OF COLD AND HOT TREATED CORRUGATED PAPER CODLING MOTH BANDS

Item No.	Treatment	Method	Average per year No. bands	Average per year Larvae per band	Percentage in Dec. Alive	Percentage in Dec. Dead	Percentage in Dec. Emerged
1	Powdered beta naphthol—1 lb.................... 104 viscosity oil—1½ pts.. Gasoline—1 pt...........	Cold	10	121	53	45	<2
2	Beta naphthol—1 lb....... 104 Viscosity oil—1½ pts.	Hot	10	156	51	47	<2

Table 2. Summary of Certain Hot and Cold Treated Beta Naphthol-Oil 4 Inch Corrugated Paper Codling Moth Bands in 1932 (Powdered Beta Naphthol Used in All Cold Treated Bands)

Item No.	Treatment	No. bands	Length in inches	Larvae per inch	Per cent on December 1, 1932 Healthy	Discolored	Dead	Emerged
1	Beta naphthol, 1 lb., 2½ lbs.; 200 vis. oil 1½ pints—gasoline 1 pint	20	773	3.2	0.8	8.5	91.5	< 1
2	Beta naphthol, 1 lb.; 72 vis. oil, 1½ pints; Gasoline, 1 pint; roofing asphalt 9% by Vol	10	482	7.1	0.3	12.6	88.5	< 1
3	Beta naphthol, 1½ lbs.; 104 vis. oil, 1½ pints; gasoline, 1 pint	5	208	5.1	6.6	27.8	65.4	< 1
4	Beta naphthol, 1 lb.; 72 vis. oil, 1½ pints; gasoline, 1 pint	11	557	5.0	11.5	36.0	52.5	< 1
5	Crude beta naphthol, 1 lb.; 220 vis. oil, 1½ pints; gasoline, 1 pint	5	259	4.9	0.3	48.2	51.5	< 1
6	Beta naphthol, 1 lb.; 300 vis. oil, 1½ pints 115° C	6	235	8 0	2.7	35.7	60.3	< 2
7	Beta naphthol, 1 lb.; 200 vis. oil, 1½ pints 115° C	11	508	1.7	0.3	55.2	42.0	< 1
8	Beta naphthol, 1 lb.; 200 vis. oil, 1½ pints 115° C	20	767	3.8	2 0	49.5	48.7	< 1
9	Beta naphthol, 1 lb.; 104 vis. oil, 1½ pints 115° C	5	244	8.0	5.2	46.6	48.2	< 1
10	No treatment	10	483	2.8	23.3	0 0	8.4	68.3

Table 3. A Comparison of the Larval Catch and Efficiency of Two and Four Inch Corrugated Paper Codling Moth Bands. Tests Conducted on the Same Trees and Four Directional Positions, Using a One-Half Band of Each Type per Tree

Item No.	Treatment	Width in inches	No. ½ bands	Length in inches	Larvae per inch	Percentage on December 1, 1932 Healthy	Discolored	Dead	Emerged
1	Powdered crude beta naphthol, 1 lb.; 300 vis. oil, 1½ pints; gasoline, 1 pint	2	47	863	7.0	6.2	40.8	51.5	< 1
2	Powdered crude beta naphthol, 1 lb.; 300 vis. oil, 1½ pints; gasoline, 1 pint	4	48	967	8.9	6.5	47.5	45.3	< 1

In 1932 a series of experiments were conducted to improve the adhesiveness of the chemicals used in the cold treated bands. A part of the results of these experiments are given in Table 2. The most effective change in formulae was the incorporation of 9% by volume liquid roofing cement into the cold mixture. This material (Item 2) increased the kill 36 per cent over the mixture without roofing cement (Item 4). In addition these black bands in this year's tests collected 31 per cent more larvae than did the bands without cement. Tests of higher ratios of roofing cement did not produce an efficient cold-treated band.

The most efficient band tested in 1932 was a cold dipped band (Table 2, Item1) This band offers promise of being one of the best beta naphthol bands yet devised The beta naphthol in the mixture had been finely ground with the oil into a factory product of the correct proportions for dipping. The combination may be either heated for hot dipping or diluted with gasoline for cold treating. The deposit of beta naphthol-oil on the bands with the cold treatment is uniform, adhesive and remained effective throughout the season.

The use of crude beta naphthol instead of the more refined product may cheapen the cost of preparing treated bands Crude beta naphthol has given as good kill of larvae as the refined product (Table 2, Item 5), (Table 3, Items 1 and 2)

Oils of 200 300 seconds viscosity, Saybolt 100°F. have proven more efficient than oils of 100 seconds, both in the cold and hot treated bands (Table 2, Items 1, 5, 6, 7, 8, and 3, 4, and 9).

In Table 2 a comparison of efficiency between Items 1 to 5, cold treated bands, and Items 6 to 9, hot treated bands, will show a decided advantage for the cold treated ones.

Table 3, Items 1 and 2 compare directly the efficiency of 2 and 4 inch bands both as to the number of larvae collected per inch and the relative toxicity of the treatments In these 1932 tests the 4 inch band collected 1.9 larvae per inch more than the 2 inch bands, or about 21 per cent. In a series of tests run during the past five years the 4 inch bands have caught a larger number of worms in all cases. From the orchardist's view point, this increased catch would more than offset the added cost of the 4 inch band.

The cost of home dipped cold beta naphthol-oil bands is very low. On a fairly large scale (20,000 feet or more) they can be made for less than 0.7c per foot of band for labor and material.

Summary

1. The cold dipped (powdered) beta naphthol-oil bands have proved as effective as the hot dipped bands.
2. The effectiveness of the cold band can be improved by the addition of 9.0 per cent roofing cement.
3. Commercially ground beta naphthol and oil is a practical and efficient mixture to use in either hot or cold bands.
4. Crude beta naphthol may be substituted for the refined product for codling moth bands.
5. Under Illinois conditions the 4 inch corrugated paper band is in general more practical than a 2 inch band.

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Mr. Parrott: May I ask in the band captures, what is the relationship of the catch to the population of worms on an apple tree?

In Illinois they caught 1,000,000 worms. How many million worms more are there in that orchard? I am very much interested in that question because in New York there is some interest in bands and we have had to carry on experiments with bands. We went into a heavily infested district where band counts last year showed an average population of worms of 300 to 900 per tree. That was preliminary work to this experiment.

Mr. Harmon who conducts the work has gotten the impression that the bands catch 25 per cent of the total worm population of a tree.

A very practical question comes up in regard to our progressive growers, the men who have the choice orchards in Western New York. By careful timing of those covers sprayed, even if you have to put on extra ones, the work has shown that you can reduce the band population of the caterpillars to two or six caterpillars per tree, while in the adjacent

parts of the orchard not so treated there is just as heavy infestation of worms in the band as last year.

What we would like to know is what per cent of the worm population do these bands catch? It is a question of evaluating these supplementary practices in regard to codling moth control.

President Flint: We have been making some attempt to answer that question by several methods. One of the methods has been to take trees in commercial orchards that have been banded, and, starting in November, to go over those trees. Some of those bands have been in place all summer without removal.

They remove the band and count the number of worms under the band. Then they go over the tree in an extremely thorough manner and by that I mean a real thoroughness. To go over a twenty-year-old tree the way we have been doing it takes at least two days and sometimes as much as four days of a man's time. I do not mean taking a few samples here and there. I mean going over the entire tree, the pruning wounds, the ground under the tree, raking up the cover under the branches, to a depth of an inch, and sifting that.

Our figures from these examinations have shown a much higher catch under the bands than we expected. On some of these trees, we found as high as 83 per cent of the worms under the band. We now have, I think, figures from approximately twenty trees where we have done that. We are accumulating more data along that line as fast as we can. These figures, as a whole, show approximately 73 per cent of the worms under the band. Last year we carried on some of these examinations in an orchard which was to be cut out later in the winter, and there we could cut any of the trees, split them open, and chop out any of the old pruning wounds, stubs or anything of that sort. We did not have to give any care to the tree at all. We were able to cover five trees in that orchard and the average from those five trees, as I remember it was 76 per cent under the bands.

In that connection, I might say in one orchard this year in the central part of the state, an old orchard with trees running from about twenty to thirty years old (that is old for an Illinois orchard) we assisted the owner in treating the bands for that orchard. He treated a little over 20,000 feet of band, using the cold-dipped method. This fall we took off a number of bands scattered over that orchard, enough, we felt, to give us a good index of what was actually occurring over the orchard. We found an average of six worms to the linear inch in those bands.

These were four-inch bands. The actual catch was over 1,500,000 worms. The emergence checked on those bands throughout the season

was—I haven't the exact figures here, but it is way under one per cent over the entire season. The bands actually cost the owner (we kept track of every item of cost) in position on the tree a trifle less than 4½ cents per tree. I do not know of any way in which he could have expended that money to better advantage in reducing the codling moth carry-over in his orchard.

That reduction, killing over 1,500,000 worms in the orchard certainly is going to have a big influence on the infestation in that orchard next year.

In the last few years the codling moth has been increasing to such an extent in Illinois that we have found it necessary to use every means possible to reduce the infestations in our well-cared for commercial orchards.

Just to give an idea of conditions, I would say this year we carried on a survey of 118 commercial orchards in the different sections of the state. Counts were made shortly before harvest in all these orchards of the actual run of the fruit to get the codling moth infestation. The infestation ran all the way from two-tenths of one per cent up to 57.8 per cent. The spray schedule had been as heavy in many of the infested orchards, even heavier, than that in some of those that were not so heavily infested.

In fact, the best orchard in the state, which is a large orchard (the orchardist operates about 600 acres) was 30 years old and had only two-tenths per cent worms. Within fifteen miles was another orchard, fifteen years old, the same variety, receiving three more sprays than the orchard with two-tenths per cent worms, which had 56 per cent worms.

The materials used in these orchards were exactly the same. The spray schedules were practically the same, and the degree of coverage was not very much different.

When you get conditions like that, you certainly have it hammered into you that there is something there other than the spray material used, which is a big factor in that infestation.

We have been stressing particularly the matter of orchard sanitation, and along with that, supplementary measures of codling moth control. One of those that we have found the most effective or most practical, considering cost and other factors, is the use of treated bands. We have been carrying on experiments in Illinois with the use of a cold-dipped band or cold-treated band, using beta-naphthol and various other materials, but the results I will give are those with beta-naphthol only.

We have found in the course of five years' work that the results obtained with the cold-dipped band are just as good or better than those

obtained with the hot treatment where the oil, the beta-naphthol mixture is heated.

MR. PARROTT: I should like to ask one more question bearing on this point. You speak of a grower in Illinois who got control of the codling moth to such an extent that less than 1 per cent was injury. What is the caterpillar count on his trees? Would that man use bands for control?

PRESIDENT FLINT: The count of his trees runs about five or six worms per band. He feels that the band under those conditions is still worth while because he is paying attention to orchard sanitation and his actual spray schedule, as far as the number of sprays he puts on, is far less than many of the neighboring growers'.

MR. HERRICK: What was the difference in which it was 57 per cent? Was it worms or stings on the fruit?

PRESIDENT FLINT: It was worms, not stings. The conditions in that orchard were extremely bad. The trees cut down were left in the orchard. The packing shed is everything it should not be. There were old crates and barrels around.

MR. HERRICK: He sprayed just as well as the other man?

PRESIDENT FLINT. He put on three more sprays.

MR. E H. SIEGLER: I should like to ask Mr. Flint relative to the deposit per foot on the band with the cold treatment compared to the hot, the amount of beta-naphthol per unit area.

PRESIDENT FLINT: I haven't the actual figures on the weights. The cold-treated band will carry a greater amount of beta-naphthol per inch or per foot, whatever linear unit you want to use, if the treatment is properly made. You can get a hot band where the temperature is just right, that will carry approximately the same amount.

MR. SIEGLER: I should like to ask what was your moth infestation in your untreated, unsprayed trees? Did you leave any trees unsprayed so we would get a relative idea as to how severe the codling moths are, if you do not spray?

PRESIDENT FLINT: We always leave an untreated check in our orchards. It was, as I recall it, 83 per cent.

MR. HORSFALL: I should like to ask what the relative proportion was of gasoline and oil in that formula. You did not give the exact formula you used.

PRESIDENT FLINT: The formula that we have been using, the one on which these results were based, is one pound of beta-naphthol, one and one-half pints of lubricating oil of 104 viscosity, and one pint of gasoline. This was for the standard band we used. The roofing solution was 9 per cent by volume. Some of the gasoline evaporates We merely put it in to make it fluid and easily dipped. You could use kerosene, but it does not evaporate as fast and we felt the kerosene residue was slightly repellent.

MR SIEGLER: Professor Parrott asked with reference to the percentage of worms caught in the bands The Bureau of Entomology has had a number of tests running for a number of years. Our figures are not as high as Professor Flint's, but the average is 30 or 50 per cent total population.

MR. C. R CUTRIGHT At the Ohio Station we have attempted to find out the worm population of the tree. There we have started with the first crop of the fruit of the season and kept a count, noting when the worm has left the apple, and have taken that figure and compared it with the total number of worms finally collected under the bands. We find we get anywhere from 8 to about 40 per cent of the worms that leave the fruit.

Of course, we admit the spread is greater because we know all the worms that leave the fruit do not finally regain the trunk or find hibernating quarters The figures in our instance are a little lower than Professor Flint's, or the Bureau's.

PRESIDENT FLINT· We have been using some other methods, too, but this one we have been using was with the idea of getting the actual per cent of worms hibernating, which is really the thing that is going to affect our next year's crop of worms in an orchard.

MR. PARROTT: We have been getting at the problem in another way, where we give trees ten-day inspections and carry off all the young apples that show eggs or stings, rearing our population in that way separate from the tree.

MR. SIEGLER: I should like to ask Professor Flint another question about the cold-dipped bands. In dipping those bands after they are dipped, what is the character of deposit, soft, or how do you provide for drainage if that is necessary? When they are placed on the tree does it run down the trunk or is it more or less adhesive to the band?

PRESIDENT FLINT: Usually the method of treating is in some sort of tank or vat, using the corrugated paper cut to desired width, whether

two or four inches, in rolls. The paper rolls should, of course, be dipped flat side down.

Some of our orchardists, one in particular who this year used some 25,000 bands, at our suggestion double dipped the bands. Those bands were 100 per cent effective right through the season. The band was dipped, then set out on a drainboard, and it is a good idea after the bands have been there for a couple of minutes to have a man turn them over. The excess runs back into the dipping tank and the material, while still slightly soft, does not run out of the band any more than it does out of the hot-treated bands. There is no running down on the trunk of the tree.

THE NET GAIN DURING THE LAST DECADE IN CODLING MOTH CONTROL INFORMATION AS INDICATED BY EXPERIENCE UNDER CONDITIONS ESPECIALLY FAVORABLE TO THE INSECT

By George M. List, *Colorado Agricultural Experiment Station, Fort Collins, Colorado*

Abstract

Extreme codling moth (*Carpocapsa pomonella*) conditions determine the true value of control suggestions in a short period of time. The proper use of arsenate of lead remains our most effective single control. Oil sprays in themselves are not a satisfactory control, but in certain combinations are of value. They complicate the spray residue problem and under many conditions are injurious to the fruit. Bait traps as a means of timing the application of sprays and the chemically treated bands are two of the most important recent developments. The use of the egg parasite, *Trichogramma minutum* Riley, has not shown a definite control under Colorado conditions. Unless more effective controls can be developed some fruit growing areas must be classed as marginal.

Colorado, with her varied altitude and the many combinations of conditions produced in the protected mountain valleys, presents in many respects a cross section of the codling moth problem of the country. There are orchards in the state where a wormy apple has never been taken and sections where the one spray method, so earnestly advocated a few years ago, could be demonstrated as the solution of the problem; still other sections, where 3, 4 and 5 sprays give a satisfactory commercial control and lastly, the Grand Valley, that incidentally has given us our codling moth reputation, where a combination of all the known controls, when put in the hands of the growers, does not give a satisfactory control, and hundreds of acres of trees have been and are being pulled as a result.

What I will have to say here is a brief summary of some conclusions

arrived at from tests and the experience of growers under these extreme conditions in contrast with those in the other sections apparently less favorable to the insect.

Fruit growers have, as a rule, been very hopeful and optimistic and have not hopelessly condemned the entomology profession for the many theories that have not added to the practical handling of this problem. Time has usually determined the true value of the various control suggestions and a surprisingly small number has stood the test. Literature is full of "sure cures" that have long since been forgotten As the time factor is much shortened under the most severe conditions, I feel justified in making a brief summary, with possibly some statements that may be contradictory to the general belief in other sections.

In spite of its many short-comings, arsenate of lead continues to be the most effective single insecticide and its proper use the most important single control Little, if any, improvement has come from using it at a greater strength than 3 pounds to 100 gallons, and no increased control has resulted from the use of the true spreaders, such as calcium caseinate and soap. Fish oils as spreaders and stickers give a more uniform coverage and increase the total load This has resulted in a slight improvement in control. But if used in more than two or three applications the difficulty in removing the residue more than offsets the benefits.

No combination of controls has allowed the applications of arsenate of lead to be reduced to a number that will not leave a residue that exceeds the legal tolerance. All fruit must be treated after harvest for residue removal. No other arsenicals have equaled the arsenate of lead in effectiveness and all stomach poisons applied as dusts have been almost useless.

The flourine compounds have not proven as effective as arsenate of lead. The difference, however, may not be so great but what some sections can use them for certain applications and thus hold the arsenical residue below the tolerance, but they do not seem to have a place under conditions of heavy infestation.

The summer oil sprays have been developed largely during the last decade and were enthusiastically received by our growers, but it is interesting to note that the use in Colorado is much less general than a few years ago. They in themselves will not control the codling moth but do increase the results when used in certain combinations. The combinations with nicotine and pyrethrum have been almost completely discarded as not giving sufficient improvement to justify the expense and there is no hope of substituting them for arsenate of lead in enough applications to hold the residue below the tolerance.

The oils, in combination with arsenate of lead, are subject to two very serious objections. The first is that even a limited number of applications very seriously complicates the spray residue problem where our residue on all fruit is several times the tolerance In many cases it has been impossible to bring the fruit below the tolerance with the present cleaning methods without serious injury.

The second objection and probably the most serious is that the application of petroleum oils, either with the arsenate of lead or as carriers of nicotine, pyrethrum or rotenone, are so generally accompanied by appreciable injury that they must be used very cautiously, and they cannot be used following dormant, delayed dormant, or summer applications of lime-sulphur without even greater injury. This injury is much more noticeable on certain varieties and on trees that are not in the most thrifty condition and seems to be accumulative at least for the season It remains to be seen just how much this effect is cumulative from season to season, but it is difficult to argue that a material that causes visible injury under any considerable variety of conditions is going to be an entirely safe insecticide to use on an insect that is as persistent as the codling moth. Under our conditions the applications must be held to two or at most three, which are not enough to carry us through our long period of high codling moth population If oils can be sufficiently refined to overcome this tendency to injury and our cleaning methods be more developed for the oil and arsenic residue, they will prove to be one of the outstanding developments for better control. But with our present knowledge we must admit that they are likely to be over-rated by the enthusiasts

Bait traps have received a great deal of attention during the past several years and there is no arguing the fact that many moths can be trapped, but in our experience the traps have not given enough improvement to warrant the labor and expense of handling them Yet, in spite of this, I think we would have to class then development as very important since they are being so successfully used in determining the codling moth activity within the orchard. They give us one of the simplest and probably the most accurate method of doing this I consider their use in this connection as far more important than as a control.

Bands have long been considered an important supplementary means of control. We have always told our growers that if they do not get a satisfactory control with 4 or 5 applications of arsenate of lead, the next thing to do is to use bands. The old bands that were worked by hand were quite effective and were almost as important in codling moth control as spraying. The chemically treated bands seem to be fully as

effective and have eliminated the tedious and rather hard work of going over the entire orchard at stated periods. We look upon the Beta-Napthol band as probably the most outstanding development in codling moth control during the last decade. We are happy to have had a small part in the development of these in cooperation with Mr E. H. Siegler, who has been the leader in this work.

The *Trichogramma minutum* egg parasite has presented a very fascinating line of work during the last several years and in the enthusiasm that comes over a new project, there is danger of us being carried away and interpreting results as we desire to see them rather than as they occur. We must admit that in our experience on this work we have seen something of that tendency, even after having developed a rather pessimistic attitude on codling moth control in this one section of the state. We have liberated several million of these parasites, representing three strains, over the last 5 years of this project. During three of these years, the effects of the liberations have been entirely masked by the natural parasitism that has occurred in the orchards If our liberations had been more general we could have taken much credit for the conditions. During the other two years there has been a low natural parasitism with the results that we could read fairly accurately the effects of the liberations. We have been disappointed in that there has been only a very light parasitism of the first brood eggs where the results should be most effective. We have not been able to explain this to our entire satisfaction. Parasitism usually begins on the last of this brood of eggs and may increase quite rapidly in orchards where the eggs are abundant The percentage of parasitism seems to be in direct ratio to the degree of infestation. In some orchards we have had as high as 80 to 90% parasitism of the late brood eggs. This, undoubtedly, has reduced the number of late worms and may reduce to a limited extent, the number of overwintering worms, but in no case has this reduction been such that there has been a marked increase in the protection of the fruit. So after these several years we are forced to the conclusion that the use of the parasite does not show a great deal of promise as a solution for our difficult problem.

Some of you will, no doubt, say that this condition of difficulty in control has developed through a failure to do this or that, or through a lack of thoroughness in work and a gradual building up of the codling moth population. There may be some truth to this, especially under the present conditions, when the morale of the growers is somewhat lowered and they are not financially able to do all of their work in the way they would like, but I think the fact remains that fruit growers,

as a rule, will fight only about as hard as they are forced to. They are usually no more thorough than they need be. That is true of all of us, whether it is against the codling moth or any other problem. So I am inclined to think that the growers, under the extreme conditions, have probably learned to be as thorough as in most localities.

There is little doubt but what our controls are not sufficiently effective to handle the situation. Unless they can be improved it appears that we must admit that there are marginal areas, made so by the codling moth and our inability to control it, where apple growing cannot be profitably conducted. Whether the insect will make further inroads upon the industry and place other localities in the marginal class I think rests with the entomologist.

So in conclusion I might say that probably one of the greatest net gains has come from the fact that science is more fully aware of the situation and is accepting the challenge. Many of the lines of attack mentioned will undoubtedly be more perfected and new ones opened up. It is hoped progress can be rapid enough to save the sections that are in a precarious condition.

Business Session of the Eastern Branch

President L. M. Peairs called for the report of the nominations committee, which was adopted.

Report of Committee on Nominations

For Chairman, T. J. Headlee.
For Secretary-Treasurer, Harry B. Weiss.
W. J. Schoene
H. W. Allen
E. N. Cory

The following report of the secretary-treasurer was read.

Report of the Secretary-Treasurer

Paid membership in the Eastern Branch for 1931 amounted to 133. For the purpose of comparison, the paid membership for previous years is given as follows:

	1929	*1930*	*1931*
West Virginia	1	1	1
Virginia	5	4	8
District of Columbia	6	3	9
Maryland	5	6	9

	1929	1930	1931
Delaware	2	2	3
Pennsylvania	9	3	11
New Jersey	26	21	19
New York	27	28	39
Connecticut	10	9	15
Rhode Island	2	0	1
Massachusetts	6	5	14
Vermont	1	1	0
New Hampshire	0	0	1
Maine	0	1	2
Canadian Provinces	1	0	0
Porto Rico	0	0	1
Totals	101	84	133

Sixty-two papers were presented at the November 1931 meeting, covering the following topics. Figures for previous years are included also.

	No. papers 1929 meeting	No. papers 1930 meeting	No papers 1931 meeting
General	2	3	1
Equipment	2	1	0
Insects injurious to animals	1	0	0
Insects injurious to ornamentals	2	5	5
Diseases and parasites of insects	3	2	8
Insecticides	6	10	9
Bees	2	0	2
Oriental fruit moth	6	3	4
Japanese beetle and related species	5	6	3
Mexican bean beetle	2	1	2
European corn borer	1	1	0
Insects injurious to fruits, vegetables and field crops	14	7	27
Wood borers	0	0	1
Totals	46	39	62

A total of 51 papers was published in the April and June 1932 issues of the Journal of Economic Entomology. These occupied 284 pages and 11 plates and the cost was $648.00. One-half of this amount was paid on July 15, 1932, and there is still a balance of $324.00 due.

Financial Statement

Cash Receipts

Balance in bank November 19, 1931	$139.22	
Additional amount received for 1931 dues	134.00	
Amount received for 1930 dues	2.00	
Amount received for 1932 dues to date	102.00	
Received for 1931 advertising	150.00	
Received for 1932 advertising to date	70.00	
Total receipts		$597.22

Cash Payments

Printing 1931 program	$ 36.50	
One-half of cost of printing 1931 proceedings	324.00	
Postage	9.45	
Expressage—material to Dr. E. P. Felt	.40	
Stationery	1.35	
Printing 1932 programs	49.00	
Government tax on two checks	.04	
Total payments		$420.74
BALANCE ON HAND December 21, 1932 (deposited in Trenton Trust Co.)		$176.48

Accounts Payable

Government tax on three checks	$ .06	
Balance unpaid on printing of 1931 proceedings	324.00	
Total accounts payable		$324.06

Respectfully submitted,
HARRY B. WEISS,
Secretary-Treasurer

The auditing committee reported as follows:

"We have examined the books of the Secretary-Treasurer and the accounts agree with the report.

December 29, 1932. H. E. Hodgkiss, W. S. Hough."

The report of the secretary-treasurer was then adopted.

Dr. C. C. Hamilton, chairman of the Program Finance Committee, reported upon the successful sale of advertising for the Branch program.

The secretary proposed the names of the following persons for affiliated membership and they were duly elected.

L. L. Hill, Ithaca, N. Y.
John A. Rodda, McCormick & Co., Inc., Baltimore, Md.
G. W. Simpson, Orono, Maine
John C. Long, Lancaster, Pa.
Frank B. Maughan, Ithaca, N. Y.
W. A. Rawlins, Ithaca, N. Y.
W. W. Thomas, California Spray Chemical Co., New York, N. Y.
Henry T. Wood, Kingston, N. Y.
Edwin Gould, Kearneysville, West Virginia
R. W. Birdsall, New York, N. Y.

EXPERIMENTAL RESULTS IN CODLING MOTH CONTROL WITH LATE SUMMER OIL APPLICATIONS

By C. R. Cutright and J. S. Houser

Abstract

Four years of experience with refined oil sprays applied in midsummer show that these materials are not as effective as arsenate of lead applied at the same time for the control of *Carpocapsa pomonella*. The ratio of entrances to stings is always higher on oil sprayed plots than on those sprayed with arsenate of lead. However, the oils used in midsummer have been quite effective in lowering the arsenical residues.

The problem of codling moth control under Ohio conditions, except in certain limited areas, is less acute than in many apple growing sections in the United States. For several years experimental work has been under way at the Ohio Agricultural Experiment Station comparing applications of summer oils alone in late season with the conventional program where arsenate of lead sprays are used. The goal sought in this investigation was not only that of worm control but the avoidance, if possible, of the necessity of washing at harvest to remove excessive arsenical residues.

The work has been conducted both in the laboratory and the field. Field results only will be presented at this time, although it may be stated that the laboratory work, in the main, substantiates the field trials.

Limited field trials of summer oils were started in 1927 and have continued to the present time. The work done prior to 1930 is not deemed of great significance for two reasons: 1st, the number of plots each year was small and there were no replicates; and, 2nd, the oil sprays available previous to 1930 had not been developed to their present stage of efficiency. However, it may be stated incidentally that all of the results during this early period, when compared with arsenate of lead-sprayed plots, were unfavorable to the oils.

In 1930 a series of four plots were sprayed with a 2% oil on July 30 and again on August 13. The data collected for these plots were compared with those from four adjacent plots which received the regular midsummer spray of arsenate of lead (1 lb.–50 gal.). The spray schedule for both series of plots was uniform during the early part of the season. Of the four comparisons, three favored arsenate of lead and one was a tie.

In 1931, the work with different summer oils was greatly increased in that 24 plots sprayed with oil in mid summer were compared with 24 adjacent plots sprayed with arsenate of lead. These paired plots were

located at five different points in Ohio and included a number of representative apple varieties. In summarizing the data of 1931 it was found that, in the matter of control, 18 of the 24 comparisons favored arsenate of lead, one favored oil, and five were ties.

During 1932, seven comparative tests between oil and arsenate of lead in midsummer were made. Of this series, four tests favored arsenate of lead, one favored the oil, and two were ties.

In all the tests from 1930 to 1932 it should be noted that in many cases the differences in results were not great. In instances where the difference was less than 4 per cent, they were recorded as ties, but where the difference was greater, the favored material is indicated. On this basis, for the 3 years' work there are 25 comparisons favoring arsenate of lead, two favoring oils, and eight ties. From these figures only one conclusion can be drawn; namely that arsenate of lead for midsummer applications was more effective than the oils used.

TABLE 1. LEAD ARSENATE VS. OILS APPLIED IN MIDSUMMER

Year	Number of trials favoring Lead arsenate	Oils	Tie
1930	3	0	1
1931	18	1	5
1932	4	1	2
Total	25	2	8

The injury done by codling moth to apple fruits usually is classified under two heads; viz., (1) entrances or sideworms and (2) stings. The data given in Table 1 were computed by combining the records for the two types of injury and expressing them as one figure.

It has been observed for some time past, while taking records from plots sprayed with arsenate of lead and with oil, that the ratio existing between stings and entrances differed for the two materials. The sting-entrance ratio of comparable plots is shown in the following table:

TABLE 2. STING-ENTRANCE RATIO EXISTING BETWEEN ADJACENT PLOTS SPRAYED WITH ARSENATE OF LEAD OR WITH OILS IN MIDSUMMER

Year	Trials	Sting-entrance ratio Lead arsenate	Oil
1930	Av. of 3	1-.8	1–1.7
1931	Av. of 20	1–.8	1– .9
1932	Av. of 7	1–.6	1–1.6
Wt. mean		1–8	1–1.2

On arsenate of lead-sprayed plots, it is easily seen that for every 10 stings there were eight entrances, while on the oil-sprayed plots for

every 10 stings there were 12 entrances. This difference can be further demonstrated by a statistical study of the data; for example, if a comparison of the oil- and the arsenate of lead-treated plots is made on a basis of entrances only, the odds are in every case significant. However, if the comparison is made on the basis of the stings, in no instance is there worth while odds. These data are presented in Table 3.

TABLE 3. STATISTICAL COMPARISON OF LEAD ARSENATE VS. OILS ON A BASIS OF ENTRANCE AND STING INJURY CONSIDERED SEPARATELY

Year	Odds showing differences between Entrances	Stings
1930—Drops	20-1	1-1
Picks	215-1	*5-1
1931—Drops	933-1	6-1
Picks	37-1	1-1
1932—Total crop	171-1	*2-1

All odds favor arsenate of lead unless marked by *.

As the entrance type of injury is much more serious than the sting, this point should be considered in evaluating the two materials.

An effort was made in 1932 to increase the efficiency of the oils by the addition of nicotine sulphate. Through the courtesy of the Standard Oil Company of Ohio we were able to collect data at Lorain, Ohio, from a series of four comparisons between midsummer applications of arsenate of lead and oil-nicotine. In this series, three comparisons favored the arsenate plots and one the oil-nicotine plot. Five small plots at Gypsum, Ohio, and seven at Wooster, Ohio, sprayed in midsummer with oil-nicotine were compared with similar adjacent plots sprayed with arsenate of lead + lime + lime-sulfur. These data are shown in the following table:

TABLE 4.—PER CENT OF FRUIT INJURED ON PLOTS SPRAYED IN MIDSUMMER

	Lead arsenate	Oil-nicotine
Gypsum, O.—1932	49.7	47.0
	27.6	36.1
	24.3	27.6
	40.0	33.2
	33.2	49.9
Mean	35.0	38.6
Wooster, O.—1932	9.0	28.2
	5.7	16.1
	11.1	11.0
	23.1	17.7
	5.8	3.6
	12.4	11.0
	11.2	11.0
Wt. mean	9.5	14.5

The trend of results in experiments where nicotine sulphate was added

to the oil slightly favors arsenate of lead, but the differences are so small that efforts to demonstrate them statistically have failed. Moreover, the sting-entrance ratio shows only a slight difference.

CONCLUSIONS.—When the data presented are considered in all their aspects, it may be said that the results demonstrate the superiority of arsenate of lead. With specific reference to the sting-entrance ratio, fewer entrances than stings were found on arsenate of lead plots and fewer stings than entrances on the oil-sprayed plots, but the total injury was higher on the oil-sprayed than the lead arsenate plots.

The possibility of using oils for late season codling moth control holds promise, particularly if the oils can be rendered more efficient by an additional toxicant of a non-arsenical nature. Small growers lacking washing equipment are more likely to use oils for late-season control than are those with acreages sufficiently large to warrant an investment in washing machinery.

In the experience accompanying the work herewith reported, in no instance have harmful arsenical residues resulted when lead arsenate was used in the calyx and first cover sprays and when oils were substituted for arsenicals in late-season sprays.

A SUMMARY OF THREE YEARS' EXPERIMENTS ON THE CONTROL OF CODLING MOTH IN SOUTHWESTERN MICHIGAN[1]

By FRANKLIN SHERMAN III, *East Lansing, Michigan*

ABSTRACT

Tests over a three-year period are reported, and show that arsenate of lead sprays may be expected to control codling moth (*Carpocapsa pomonella*) in heavily infested Michigan orchards. Summer oil emulsions and the summer oil-nicotine sulphate combinations have also resulted in good control under severe infestations. Following the use of lead arsenate sprays it was necessary to wash the fruit. This, it is shown, usually can be escaped if summer oils or the summer oil-nicotine sulphate combination is used for the summer brood sprays. It is shown that moth traps furnish valuable information which may be utilized in the spraying program. The importance of reducing codling moth population by supplementary control measures in severely infested orchards is emphasized.

During the past three seasons, 1930 to 1932, inclusive, the writer has conducted control experiments on codling moth near Fennville, Michigan. L. J. Gentner, formerly of the Department of Entomology, Michigan State College, conducted similar experiments in this region

[1]Journal Article No. 142 (n. s.) from the Mich. Agr. Exp. Sta.

during 1928–29. Reports on three years' experiments in this region have appeared elsewhere.[2] This report covers the years 1930–32, inclusive, and includes only the writer's experiments.

Weather conditions of the past three seasons have accentuated the increase of codling moth in Michigan. There have been unusual periods of high temperature, as well as long periods of dry weather throughout these three seasons. There are many semi-deserted orchards in the Fennville district, as well as many old bearing trees, in which the control of codling moth has become a serious problem. In such orchards the insect finds excellent opportunities for passing the winter safely. There are also packing houses and cider mills in the vicinity, both of which have contributed towards building up the codling moth population.

The experiments reported were undertaken with the following objectives in mind:

1. To formulate a spraying program that would most satisfactorily meet conditions in the Fennville region.
2. To test as many insecticides as time and labor would permit in an attempt to find a satisfactory substitute for arsenate of lead that would eliminate washing the fruit.
3. To determine what degree of control might be secured with the standard lead arsenate sprays, because many of the growers were beginning to believe that the lead arsenate sprays were not as effective as they had been in the past.
4. To test bait pan traps as indicators of moth activity in the orchard and to observe their value in timing the cover and second brood sprays.
5. To determine the effect scraping and banding the trees has in reducing codling moth population.

Equipment and Methods.—During the early part of 1930, sprays were applied with a team-drawn power sprayer. This outfit was badly worn and many delays were caused by break-downs. In August, 1930, the College purchased a Bean power sprayer, mounted on a truck. This machine has been used for applying all sprays since that date. The trees were sprayed both from the ground and tank in order to obtain as thorough coverage as possible. When spraying from the tank, multi-nozzled spray guns were usually employed, but single-nozzled spray guns were used when spraying from the ground, as well as from the inside of the trees. The writer sprayed all plats himself.

Materials Tested in Experiments.—Three materials have so far indicated that they may be used with success for controlling codling

[2]Journal of Economic Entomology, Vol. 24, October, 1931. Mich. Agr. Exp. Sta., Special Bul. 221, 1932.

TABLE 1. DATA SHOWING CONTROL OF CODLING MOTH WITH ARSENATE OF LEAD SPRAYS, FENNVILLE, MICHIGAN

Variety	Year	Treatment*	Wormy Per cent	Per cent stung	Per cent sound	Residue analysis†
Jonathan	1930	3 lbs. lead arsenate—Calyx, 3 cover sprays Two summer brood sprays	1.9	19.2	78.9	.022
	1931	3 lbs. lead arsenate—Calyx, 4 cover sprays Three summer brood sprays	1.2	7.5	91.3	.050
	1932	3 lbs. lead arsenate—Calyx, 4 cover sprays Three summer brood sprays	1.6	7.1	91.3	.038
Hubbardston	1931	3 lbs. lead arsenate—Calyx, 4 cover sprays Three summer brood sprays	8.3	32.3	59.4	.030
	1932	3 lbs. lead arsenate—Calyx, 4 cover sprays Three summer brood sprays	6.9	10.6	82.5	.028
Wolf River	1931	3 lbs. lead arsenate—Calyx, 4 cover sprays Three summer brood sprays	25.9	29.2	44.9	.020
	1932	3 lbs. lead arsenate—Calyx, 4 cover sprays Three summer brood sprays	10.8	7.8	81.4	.037

*Materials used in 100 gallons of spray. Lime sulphur 2½ gallons included in calyx and first two cover sprays.
†Courtesy State Analyst, Michigan State Department of Agriculture, Lansing.
NOTE: All apples which dropped to the ground, as well as those that were harvested, were examined and are included in the figures.

moth. These materials are arsenate of lead, two per cent summer oil emulsions, and one per cent summer oil emulsions with three-fourths of a pint of nicotine sulphate in one hundred gallons of spray. These materials will be considered in this report by presenting the results in tabular form.

ARSENATE OF LEAD SPRAYS —Within the past five years many growers in southwestern Michigan have complained that the lead arsenate sprays were not affording satisfactory control. With these complaints in mind, tests with lead arsenate sprays were conducted each year. One plat was sprayed as was indicated in the college Spraying Calendar and the other plats were sprayed more often when the occasion demanded. The following figures, presented in tabular form, show the best control obtained each year with arsenate of lead sprays

With Jonathans the control has been fairly satisfactory yearly, but improved markedly during 1931 and '32. The writer did not spray Hubbardstons or Wolf Rivers with arsenate of lead sprays during the season of 1930, but during these seasons observed the results obtained by the grower, who sprayed these varieties with arsenate of lead sprays The Wolf Rivers yielded only about fifteen per cent of uninjured fruit, while the Hubbardstons yielded about twenty per cent of uninjured fruit. Samples tested for arsenical residue, on all plats which had received arsenate of lead sprays throughout the season, exceeded the tolerance The spraying program on the plats during the 1931 and 1932 seasons was practically the same. In each of these years, the plats received two more sprays than during the 1930 season. This was because it was found necessary to include one more cover spray during late July and as well a third spray for the summer brood It should be mentioned here that before the 1931 season, all Jonathan and Wolf River trees in the orchard were scraped and banded. The Hubbardstons were scraped and banded before the 1932 season During the 1931 and,'32 seasons, bait pan moth traps were employed as indicators for timing the cover and summer brood sprays. It is believed that the supplementary measures, rather than the changes in the spraying program deserve credit for the improved control during 1931 and '32. The basis for this belief is the fact that there was a greatly improved control in 1932 over that of 1931, during which time the spraying program remained the same.

SUMMER OIL-NICOTINE SULPHATE COMBINATIONS.—(Summer Oil 1% Black Leaf 40 ¾ pint in 100 gallons). This combination has been tested during the past three years in the orchard containing the plats reported in Table 1. The plats reported in Table 2 received the regular lead

TABLE 2. DATA SHOWING CONTROL OF CODLING MOTH WITH SUMMER OIL-NICOTINE SULPHATE COMBINATION SPRAYS, FENNVILLE, MICHIGAN

Variety	Year	Treatment*	Wormy per cent	Per cent stung	Per cent sound	Residue analysis†
Jonathan	1930	Calyx and 3 cover sprays, 3 lbs. lead arsenate, spring brood. Two sprays "Orthol K. Med." 3 qts., "B. L. 40" ¾ pt., summer brood.	22.1	34.9	43.0	.007
	1931	Calyx, 4 cover sprays. 3 lbs. lead arsenate, spring brood. 3 applications 1% "Orthol K. Med." ¾ pt. "B. L. 40," summer brood	4.8	12.4	82.8	.004
	1932	Calyx, 4 cover sprays. 3 lbs. lead arsenate, spring brood. 4 applications 1% "Orthol K. Med." ¾ pt. "B. L. 40," summer brood	3.7	7.1	89.2	.007
Hubbardston	1931	Calyx, 4 cover sprays, 3 lbs. lead arsenate, spring brood. 4 applications 1% "Orthol K. Med." ¾ pt. "B. L. 40," summer brood	7.8	41.3	50.9	.011
	1932	Calyx, 4 cover sprays, 3 lbs. lead arsenate, spring brood. 4 applications 1% "Orthol K Med." ¾ pt. "B. L. 40," summer brood	11.2	13.8	75.0	.010
Wolf River	1930	Calyx, 3 cover sprays, 3 lbs. lead arsenate, spring brood. Two sprays "Sunoco" 1 gal., "B. L. 40," ¾ pt., summer brood	69.9	14.8	15.3	.010
	1931	Calyx, 4 cover sprays, 3 lbs. lead arsenate, spring brood. 4 sprays "Orthol K. Med." 1%, ¾ pt. "B. L. 40," for summer brood	49.6	16.2	34.2	.010
	1932	Calyx, 4 cover sprays, 3 lbs. lead arsenate, spring brood. 4 sprays "Orthol K. Med." 1%, ¾ pt. "B. L. 40," for summer brood	19.3	8.7	72.0	.007

*Materials used in 100 gallons of spray. Lime sulphur 2½ gallons included in calyx and first two cover sprays.
†Courtesy State Analyst, Michigan State Department of Agriculture, Lansing.
NOTE: All apples which dropped to the ground, as well as those that were harvested, were examined and are included in the figures.

arsenate sprays for the calyx and first brood cover sprays, but the oil-nicotine sulphate combination was substituted for the summer brood sprays. The control shown in Table 2 should furnish a fair basis for the comparison of this combination spray with the sprays of lead arsenate as shown in Table 1.

The figures in Table 2 show, in the same manner as those in Table 1, that control has improved during the three-year period. However, when comparing the control secured in the oil-nicotine sulphate plats with the control secured in the lead arsenate plats, it should be explained that during the 1931–32 season the oil-nicotine sulphate plats received four summer brood sprays, while the arsenate of lead plats received only three sprays over the same period.

Summer Oil Emulsions.—(2 gallons in 100 gallons of spray). Summer oil emulsions have been tested the past three seasons, as substitutes for lead arsenate in the summer brood sprays. The results of these tests are given in Table 3 below. These tests were conducted in the orchards that included the plats reported in Tables 1 and 2.

Table 3, as Tables 1 and 2, shows that a very good control was secured during the 1932 season on Jonathans and a highly improved control is shown on Wolf Rivers and Hubbardstons

A prospectus of the data presented shows a greatly improved control in 1932 over that of 1931, during which years the spray applications were practically the same. We are convinced that the improved control was due largely to the supplementary measures, which included scraping and banding and the use of moth traps for timing sprays

It is also definitely shown that lead arsenate sprays are proving successful under conditions of severe codling moth infestation in Michigan, and that the oil-nicotine sulphate combination and summer oil emulsion sprays give a very satisfactory control, although more applications appear to be necessary when these sprays are used, thereby increasing the cost. This cost is partly offset, in many cases, by the fact that the apples receiving these sprays may escape the necessity for washing. This, however, does not always follow, since in some cases there has been sufficient residue on the apples from the early arsenical sprays to necessitate its removal. The plats included in these tables do not represent all of our tests, but we believe that they represent a fair comparison, at least of these three materials, in a heavily-infested Michigan orchard.

In addition to these materials, the following sprays have been tested, in the same orchard, but have failed to approach lead arsenate in effectiveness: (1) Paris green, used through the season; (2) Paris green,

TABLE 3. DATA SHOWING CONTROL OF CODLING MOTH WITH SUMMER OIL EMULSION SPRAYS, FENNVILLE, MICHIGAN

Variety	Year	Treatment*	Per cent wormy	Per cent stung	Per cent sound	Residue analysis†
Jonathan....	1930	Calyx, 3 cover sprays 3 lbs. lead arsenate. Two summer brood sprays, 1½ gal. "Orthol K. Med."	19.9	29.7	50.4	.010
	1931	Calyx, 4 cover sprays, 3 lbs. lead arsenate. 3 summer brood sprays, 2 gal. "Orthol K. Med."	7.4	17.5	75.1	.018
	1932	Calyx, 4 cover sprays, 3 lbs. lead arsenate. 4 summer brood sprays, 2 gals. "Orthol K. Med."	1.1	3 0	95.9	.007
Hubbardstons	1930	Calyx, 3 cover sprays, 3 lbs. lead arsenate. Two summer brood sprays, 1½ gal. "Orthol K. Med."	20.9	39 6	39.5	.010
	1931	Calyx, 4 cover sprays, 3 lbs. lead arsenate. 3 summer brood sprays, 2 gals. "Orthol K. Med."	16.8	43.4	39.8	.011
	1932	Calyx, 4 cover sprays, 3 lbs. lead arsenate. 4 summer brood sprays, 2 gals. "Orthol K. Med."	11.3	13.8	84.6	.005
Wolf River...	1931	Calyx, 4 cover sprays, 3 lbs. lead arsenate. 3 summer brood sprays, 2 gals. "Orthol K. Med."	25.9	29.2	44.9	.012
	1932	Calyx, 4 cover sprays, 3 lbs. lead arsenate. 4 summer brood sprays, 2 gals. "Orthol K. Med."	10.8	7.8	81.4	.007

*Materials used in 100 gallons of spray, lime sulphur 2½ gallons, included in calyx and first two cover sprays.
†Courtesy State Analyst, Michigan State Department of Agriculture, Lansing.
NOTE: All apples which dropped to the ground, as well as those that were harvested, were examined and are included in the figures.

used for the summer brood sprays only; (3) White oil and pyrethrum, used throughout the season; (5) Cryolite, used for summer brood sprays only; (6) Nicotine sulphate and tannic acid, used for the summer brood sprays only. Barium fluosilicate, four pounds, with one quart of summer oil in each hundred gallons of spray, used as a sticker, was tested on one plat of Jonathans (1932) that produced 91.4 per cent of uninjured fruit. It is expected that this material will be given a more complete trial during the next season.

THE USE OF MOTH TRAPS FOR TIMING SPRAY APPLICATIONS.—For the past two seasons we have used a number of moth traps in our plats, and have kept daily records of the number of moths captured in them. These records have shown clearly that there were certain periods of heavy moth flight in the orchard. They have also shown that the summer brood moths may continue their activity later some years than on other years This means that a variable number of sprays may be necessary, from year to year, for the summer brood, depending on the duration of moth flight. It appears from our observations that time and trouble expended in caring for several of these moth traps may repay a grower many times by permitting an accurate timing of cover sprays and by giving warning of late flights of moths or by preventing a useless spray application after moth flight has ceased.

SCRAPING AND BANDING.—Following the poor control obtained during the 1931 season, the attempt was made to reduce the population of codling moth in the orchard by scraping the trees and banding them with chemically treated (Beta naphthol) cardboard bands. To obtain data revealing the number of larvae passing the winter on the trees, the following observations were made In the fall of 1930 five Wolf River trees were scraped and banded with burlap sacks to determine how many codling moth larvae might be hibernating on the trees. In the spring these bands were removed and the larvae counted. This was repeated in 1932, except that chemically treated bands were used to capture the larvae. The number of larvae captured each year was as follows:

	Live larvae 1931	Live larvae 1932
Tree 1	267	87
" 2	164	64
" 3	329	76
" 4	509	47
" 5	186	56
Total 5 trees	1455	330

The five trees were selected at random in the orchard and indicate the number of larvae entering hibernation on the trees. It is seen from the above figures that the larvae were reduced in 1932 to less than one-fourth the number present in 1931.

To determine the number of larvae that were passing the winter on the trees under natural conditions, five Jonathan trees were selected at random and were carefully scraped and examined. The number of larvae on each tree and the position from which they were taken is shown in Table 4.

TABLE 4. CODLING MOTH LARVAE PASSING WINTER ON TREES. DU VALL ORCHARD, FENNVILLE, MICHIGAN, 1931

Tree	Below crotch	Crotch	Above crotch	Total
1	38	11	8	57
2	46	6	4	56
3	61	14	7	82
4	26	4	5	35
5	54	5	3	62
Total, 5 trees	225	40	27	292

Table 4 indicates the number of larvae that had passed the winter beneath the bark on the trees. These larvae escaped all natural enemies and most of them would have emerged as moths later in the spring. Only one tree (No. 5 in Table 4) was examined in this manner during the 1932 season, and only ten larvae were found; 82 larvae were removed from this tree in 1931. Six of these larvae were above the crotch, one in the crotch, and three below the crotch. More larvae passed the winter on the five trees beneath the burlap bands, because they secured protection from woodpeckers and some of their other natural enemies. That many orchards in the Fennville District are even more heavily infested than this seems certain from the records of our catches in moth traps.

SUMMARY

1. Weather conditions have so favored the increase of codling moth population in some Michigan orchards that control has become a serious problem.

2. Three materials: Lead arsenate, summer oil-nicotine sulphate combination, and two per cent summer oil emulsions, have given good control in heavily infested orchards.

3. An excessive arsenical residue, which must be removed from the fruit, followed successful control with lead arsenate sprays.

4. With few exceptions, when non-arsenicals were used in the summer brood sprays, the arsenical residue was within the limits of tolerance.

5. Bait pan moth traps were found valuable for timing cover sprays and for determining the necessary number of summer brood sprays.

6. Although a heavy spraying schedule was followed with all of the materials tested, satisfactory control was obtained only after the codling moth population was materially reduced by scraping and banding the trees.

DR. B. F. DRIGGERS: I should like to ask Dr. Hutson if he had a block sprayed the same as the banded and scraped block, that did not have the trees banded and scraped. What was the infestation in this block?

DR. HUTSON: This was conducted in an orchard, the plots taking up the entire orchard. The orchard beside it, with nothing more between them than a ditch, was sprayed with the standard lead arsenate treatment and was not scraped and banded. In that orchard, the infestation, the wormy fruit, worms and stings combined, ran from 35 to 40 per cent.

THE TECHNIQUE OF CODLING MOTH FIELD EXPERIMENTS

By C. R. CUTRIGHT and H. F. DIETZ, *Wooster, Ohio*

ABSTRACT

In this paper the principles that should govern the planning of any codling moth (*Carpocapsa pomonella*) field experiment are discussed in detail. The proper size of the plot and the arrangement of the plots in randomized blocks is considered as being of major importance. The equipment necessary for handling efficiently such an experiment is discussed together with methods of sampling, data collection, and final analysis of data. It is considered that the importance of the field experiment warrants its greater usage in the future.

The term "technique", which usually implies the manual handling of an experiment or operation, may easily be extended to include preliminary arrangements, the conduct of the experiment, and the final collecting and analysis of data. In this paper the more inclusive meaning is used.

The barriers to successful field experimentation with codling moth are many. They present themselves in the earliest preliminaries, continue during the entire life of the experiment, and, if anything, increase

their numbers during the collecting and analysis of field data. So numerous are these difficulties that workers have, in many instances, taken their problems into the laboratory, hoping in this way to escape some of them. In this manner much progress has been made, but the fact remains that the field experiment is the final court in which the ultimate value of any idea, material, or system is proven. The writers believe in the field experiment despite the difficulties inherent in it. Our findings have been of great interest to us, and we believe that many of the inherent difficulties can be overcome.

The first mistake in codling moth experimentation to be avoided is that of considering seriously data from plots in an orchard serving its first year of experimental use. The entomologists should "know his orchard," and such knowledge is gained only after 1 or 2 years of experience in it. By such knowledge we mean that one should acquire: 1st, a good general idea of the infestation as it exists in different sections of the orchard; 2nd, an idea of crop yields and conditions in the orchard as a whole; and, 3rd, some conception of what to expect in individual tree infestation. It is only when one has these points in mind that an intelligent analysis of the data can be made.

The great variability in infestation existing between adjacent trees, even though these were of the same variety, age, size, crop yield, and spray treatment, was recognized by workers with codling moth many years ago The large plot was proposed and used to offset this difficulty. Size of plot was considered to be essential to accuracy, and, for this reason, there are records from plots of over an acre of trees being used as a unit. Such use of large plots creates very serious difficulties as can be seen by considering the following points: First, with large plots accurate comparisons are made more difficult because of possibly greater variability in soil types and topography, these being reflected in different rates of infestation. Second, despite possible variation between adjacent trees, the fact remains that increasing the distance between units to be compared also increases the possible chances for variation. Third, large plots demand a tremendous amount of labor, not only in the application of sprays throughout the season but also in the final collection of data. If the large plot is used, it is done at the expense of the necessary replications; this frequently impairs the value of the data collected. Fourth, the use of large plots demands large orchards uniform as to variety, age, size, soil type, topography, and crop prospect. The difficulty of securing such an orchard for experimental use can be appreciated only by one who has tried to secure one. Fifth, for various reasons which we will not attempt to discuss here, there are always

areas of varying infestation to be found in orchards of any size. A large plot will frequently cover areas of either high or low injury, and the material being used is thereby given a false value. Variation that may occur due to position is illustrated in the following table:

TABLE 1. LARGE PLOTS TREATED ALIKE COMPARED WITH LARGE PLOTS TREATED DIFFERENTLY

	Per cent infestation							Max. var.
	1st Example							
Same spray treatment, 1932...	25.8	16.1	16.4	18.6	13.5	12.1	10.4	15.4
Different spray treatment, 1932	9.5	11.3	14.2	19.6	14.5	13.3		10.1
	2nd Example							
Same spray treatment, 1932..	48.2	41.6	33.6	36.1	42.9			14.6
Different spray treatment, 1931	34.6	24.0	23.1	30.9	22.4			12.2
	3rd Example							
Same spray treatment, 1932...	42.8	47.1	32.1	24.5	29.2			18.3
Different spray treatment, 1930	21.4	24.7	27.6	17.3	24.6			10.3

In the first example, there are seven large plots, averaging over 15 trees each, that were similarly treated throughout the season. Seven trees from each plot were sampled to secure the data that appear in the first horizontal column. In the column immediately below are shown the per cent of infestation on a series of trees treated with different materials As with the preceding series, seven trees were sampled to secure each figure. In the first series, the difference due to position is 15.4, whereas in the second series the difference between materials is 10.1. No relationship or correlation exists or is intended in the vertical columns Under Example 2 there is a similar set of data, except that the figures from similarly treated plots were taken in 1932 while those from plots treated with different materials were secured in 1931. The plots of 1932 occupied identically the same ground as the plots of 1931, and the data were taken in the same manner; therefore, a relationship exists in the vertical columns. Example 3 shows another set of data identical with Example 2, except that a space of 2 years separates the collection of data. Only a brief study of this table is needed to convince one of the futility of control data collected from large plots without proper replication.

Over 300 trees were used in obtaining the data shown in Table 1. In Table 2, only 34 trees, or one-tenth of the number given in the large-block method, were used to determine the relative efficiency of two different materials. The replications were placed at three different points in Ohio. In one locality seven replications were used, and in the

other two localities five replications were used in each. A study of these data and their statistical analysis shows conclusively that Material A was superior to Material B. Thus, at approximately one-tenth the labor and expense, we have obtained definite and conclusive results which were not secured from the large plot experiments.

TABLE 2. A COMPARISON OF TWO SPRAY MATERIALS USED IN THE ONE-TREE-PLOT SYSTEM

	Per cent infestation, 1932							Wt M.
	1st Example							
Material A	9.0	5.7	11.1	23.1	5.8	12.4	11.2	9.5
Material B	26.2	30.1	12.8	21.5	16.6	13.4	10.9	19.6
	2nd Example							
Material A	40.7	47.7	34.0	15.0	21.4			32.5
Material B	50.3	72.5	37.1	31.8	35.4			39.3
	3rd Example							Ar.M.
Material A	49.7	27.6	24.3	40.0	33.2			35.0
Material B	57.0	44.3	44.3	38.1	46.6			46.1

A comparison of Tables 1 and 2 indicates the following advantages for the small-plot or one-tree-plot experiments:

(1) The necessary replications for the securing of accurate data are obtained at a minimum of expenditure of time and labor. Replications serve two definite purposes—(a) the error to which field results are subject is diminished, and (b) an estimate of the error is obtained which can be secured in no other way An experiment without replications yields an isolated figure unsupported by others whose relationship is known through the estimate of error.

(2) Such disadvantages of the large-plot experiment as the influence of topography, difference in soil, difference in infestation, and difference in yield are avoided.

(3) Orchards containing badly mixed varieties, vacant spaces, and trees of different ages and unequal crop prospects may be utilized.

(4) Through the use of small or of single-tree plots, the experiments can be much more easily and definitely arranged to permit the application of tests of significance in the final analysis of data.

This implies that the investigator has in mind the use to which his data will be applied, even before the experiments are begun.

The greatest disadvantage in the use of small plots lies in the mechanical application of the spray to the tree. Spray drift must be avoided. Two years' experience with this method shows that the avoidance of spray drift is not a particularly difficult matter.

Small plots necessitate considerably more driving through the orchard

than do large ones, but, since the total size of the experiments is materially decreased, this extra driving becomes a negligible factor.

An objection that has been raised against the small or one-tree plots is that moth migration from a possibly heavily infested plot may alter the results after the regular spray schedule has been applied. However, the experience of 2 years with heavily infested check trees distributed among treated blocks shows that this migration is not an important factor where a good or efficient protective material has been used.

The late Anthony Spuler has been quoted as saying "that every individual tree maintains its own individual rate of infestation even from year to year." Our own experience gives considerable evidence of the accuracy of this statement.

As previously indicated, a satisfactory arrangement is greatly facilitated by the use of small plots. There are several possible arrangements from which the data can be readily analyzed. It is probable that the best of these is the randomized block, as shown in Fig. 33. Here we have three treatments with six replications each. In each of the six blocks each treatment appears once, the position of which is selected at random. The data from such an arrangement can be subjected to analysis of variance and co-variance, which are among the most satisfactory types of statistical study.

THE MECHANICAL HANDLING OF EXPERIMENTS.—Good equipment of a particular type is essential to the handling of such arrangements as we have described. It has been found that a sprayer with a calibrated tank of 100 to 150 gallon capacity answers this purpose very satisfactorily. The outfit should be motorized in order to facilitate rapid movement between blocks. A spray gun is the most desirable applicator because it allows accurate placement of spray, is not burdensome, and may be used in light breezes without serious drift.

Thoroughness of application is essential to good control, since the tree as a whole is under test. Hence, it is obvious that the tree should be undersprayed, as well as covered from the outside. Underspraying also has the advantage of avoiding considerable drift.

SAMPLING.— Though satisfactory analysis of data depends on the accuracy of the samples taken, sampling in itself is a process not to be confused with analysis.

In codling moth experiments, where the volume of the crop prevents its inspection in entirety, the sampling is done by selecting a portion of the fruit borne by the tree. This fruit falls into two large classes; namely the drops and the picked fruit or picks.

Obviously, both classes must be sampled in order that the following relationships between the classes can be determined and a final figure obtained which represents the condition of the whole. We must know the relation of the sample of the drops to the total drops, to the picked

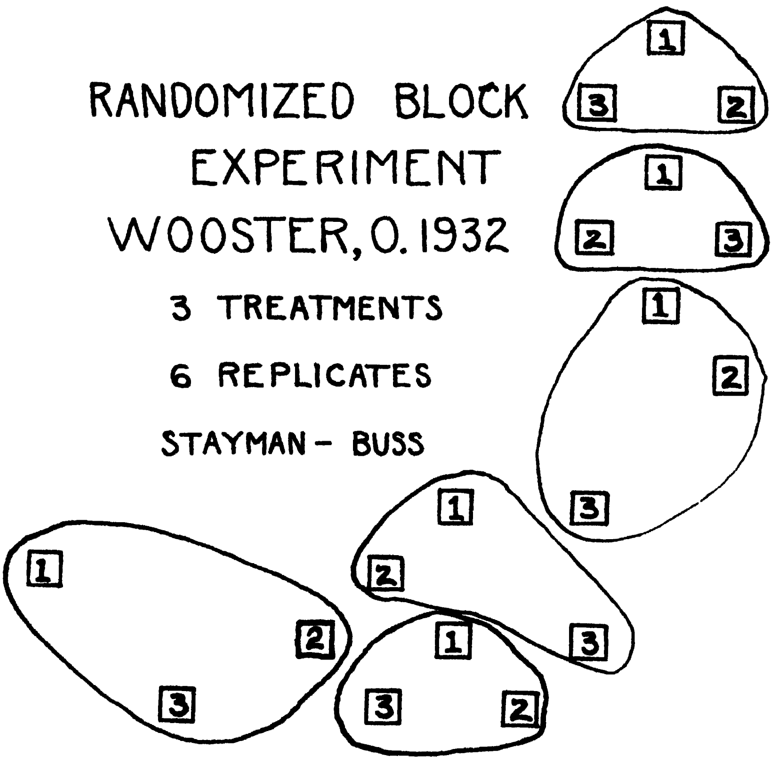


FIG. 33.--Layout of randomized block experiment, Wooster, Ohio, 1932.

fruit sample, to the total picked fruit, and to the total crop (which includes all drops and picked fruit). A similar relationship must be determined for the picked fruit sample.

This is shown in part by the following table, the primary purpose of which is to bring out the influence of the drop count on the total infestation under varying intensities of codling moth population.

Since apples are constantly falling from the trees throughout the season we adopted the practice of beginning our drop counts as soon as the differentiating influence of the spray treatments was expected to be evident. Thus, if the spray differentiation started early in the season, the counts were started about the middle of July and continued at definite intervals, usually 10 days to 2 weeks, until picking time. Ob-

viously, where spray differentiation did not begin until later in the season, the beginning of drop counts was correspondingly delayed. In practically all experiments that have been conducted to date, all drops have been counted and scored.

TABLE 3. INFLUENCE OF DROP COUNT ON FINAL RESULTS

Per cent injury on drops	Per cent injury on picks	Per cent injury on total crop
31.0	28.1	28.2
48.4	25.9	34.5
60.6	31.5	43.3
82.4	44.8	60.0

The method of recording the drop count and scoring as it is obtained throughout the season is shown by Fig. 34. This method has the advantage of permitting a tentative analysis of the data at any time during the course of the experiment.

The method of sampling the picked fruits has been as follows: In most instances the crop of picked fruit is too large to be scored in its entirety. Therefore, it has been necessary to select a representative sample from the tree. Representative and proportionate numbers of fruits from the top, middle, and lower portion of all sides of the tree must be taken. This may be done by picking vertical sectors from various sides of the tree or by taking random samples from all parts and sides of the tree. This work can be done by unskilled labor under proper instruction and supervision. It is highly important to have an accurate estimate of the total number of fruits borne by the tree. This is secured by counting the sample into bushel lots. The average number of fruits per bushel is thus obtained and the total number of bushels borne by the tree is multiplied by it. An experimental count by this method shows that it is very accurate.

The selection of samples of picked fruit from random crates on the ground has proved to be an unsatisfactory method of sampling a crop.

All scoring is done in the orchard immediately after the fruit has been picked from the tree. This is perhaps the most simple and accurate method, since any possible confusion arising from transportation to a central counting point is avoided.

In all experiments that have been conducted to date, from 20 to 100 per cent of all fruit borne by the tree has been counted.

The scoring crew consists of three men. Two of them are equipped with automatic hand counters and score the fruit, counting each individual apple as handled. The injuries are called aloud to the third member, who records them on a battery of automatic counters. At the comple-

tion of the count on each unit the record is entered in the field notes and all counters reset at zero. A crew of this kind, without undue effort, can score from 20,000 to 25,000 fruits per day.

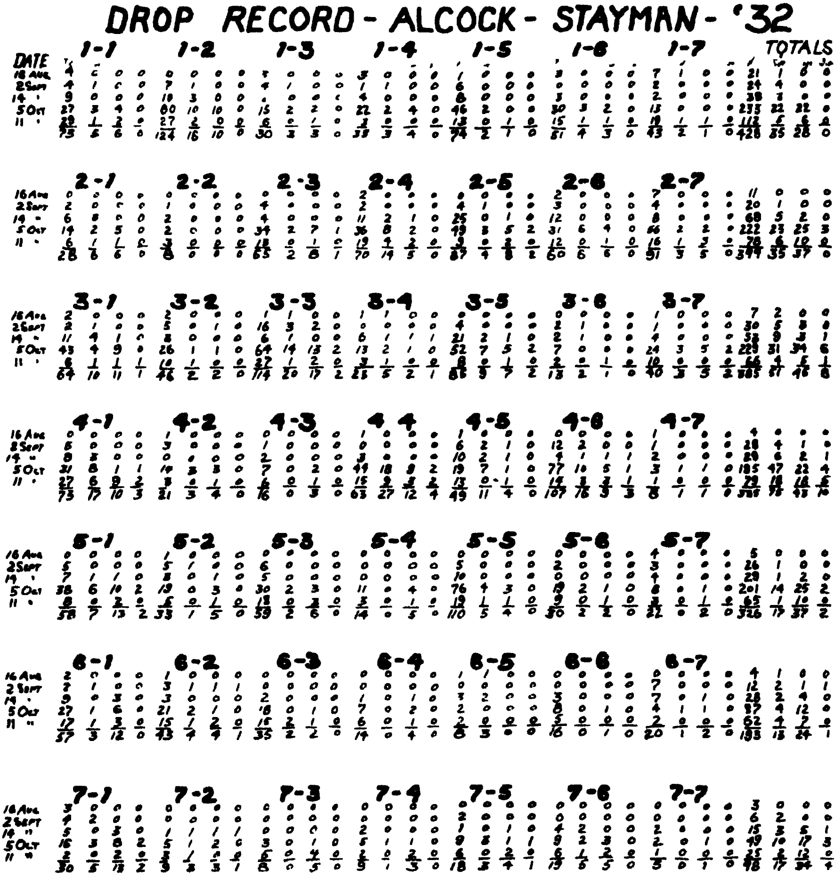


FIG. 34.—A season's record of dropped fruits from an experimental orchard.

Several different methods of recording injuries may be used: (1) Apples injured by entrances, (2) individual entrances, (3) apples injured by stings, (4) individual stings, (5) the combination of individual entrances and stings, and (6) a combination of fruits injured by entrances and stings. The last named method is the one that has been employed in all experimental work to date. This has been used because it is self-evident that the injury caused by codling moth is a combination of both entrances and stings. Hence, it would be obviously unfair to use any of the first four methods alone.

The method of counting all individual entrances and stings, recording them separately, and then combining them to obtain one representative figure is undoubtedly the most nearly accurate method, but it has the disadvantage of slowing down the counting appreciably.

In Table 4 is shown a comparison obtained by using the last two systems. It will be noted that the recording of all individual injuries is the more critical method, since it creates a final difference of greater magnitude than when fruits bearing both types of injury are combined and counted as a unit. It will be noted, however, that the actual difference between treatments is definitely established by Method 6.

TABLE 4. COMPARISON OF TWO METHODS OF SCORING INJURIES

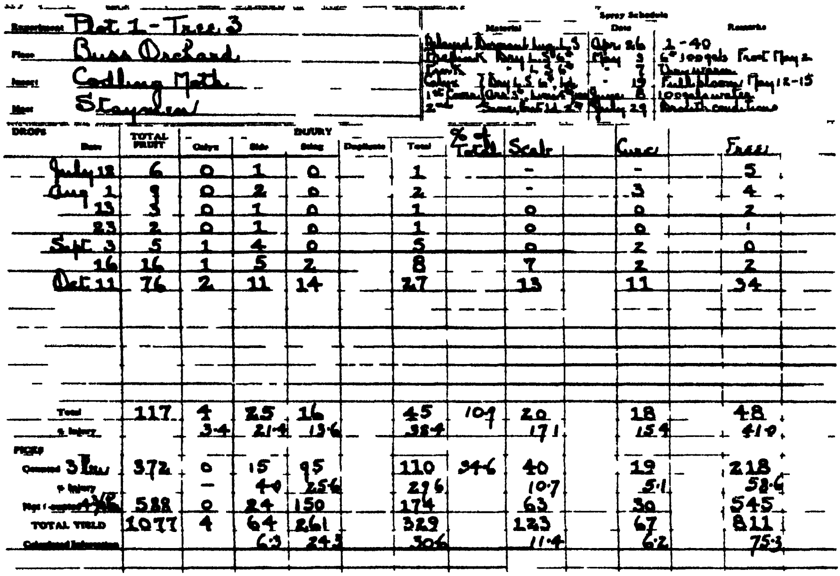
No. fruits examined	Per cent fruits injured by entrances	Per cent entrances	Per cent increase
523	6.1	8.4	.37
568	12.1	18.1	.50
397	32.2	52.7	.63

Where time permits, it is desirable to make the individual injury the unit for scoring because of the greater differentiation of the results obtained. If time is short, this greater differentiation is offset by using the injured fruit as the unit because of the inclusion in the final count of a much larger number.

When all data have been collected in the field they are assembled in the office in the manner shown in Fig. 35. The data from each individual unit serving as a plot, whether a single tree or a group of trees, are collected on the sheet as shown. This includes each individual tree-drop count, the record at harvest time, and other data essential to the experiment. It has the advantage that the data are in such form that they can be readily taken from the sheet and analyzed. Where single-tree plots are used, these data sheets give a record of the performance of any individual tree from year to year.

CONCLUSION.—Three seasons' experience with codling moth field control experiments, in which the results obtained from large plots were compared with those obtained from replicated single-tree or small plots, shows a decided advantage for the latter system. Not only does the small plot save time and labor, but it has the greater advantages of permitting the increased use of replications, desirable plot arrangements, and a more complete collection and analysis of pertinent data, which are precluded by the use of large plots. Furthermore, it would seem that this, or a similar system, if adopted by codling moth investigators in widely separated regions, would be a great aid in securing data which would be directly comparable. The details of such a system need not

necessarily follow those outlined in this paper as these have been given largely for illustrative purposes.



Drops Date	Total Fruit	Calyx	Side	Sting	Duplicate	Total	% of Total	Scale	Curc	Free
July 12	6	0	1	0		1		-	-	5
Aug 1	9	0	2	0		2		-	3	4
13	3	0	1	0		1		0	0	2
23	2	0	1	0		1		0	0	1
Sept 3	5	1	4	0		5		0	2	0
16	16	1	5	2		8		7	2	2
Oct 11	76	2	11	14		27		13	11	34
Total	117	4	25	16		45	10.4	20	18	48
% Injury		3.4	21.4	13.6		38.4		17.1	15.4	41.0
Picks Commercial 3 Bu	372	0	15	95		110	34.6	40	19	218
% Injury		—	4.0	25.6		29.6		10.7	5.1	58.6
Not commercial 4 1/2	588	0	24	150		174		63	30	545
TOTAL YIELD	1077	4	64	261		329		123	67	811
Calculated Information			6.3	24.3		30.6		11.4	6.2	75.3

FIG. 35 – Sample data sheet showing a complete season's record for a tree used in codling moth work

DR C C. HAMILTON: I should like to ask Dr. Cutright if in the first charts where he had his series of blocks across the field sprayed with the same material one year, and then the same plots sprayed with different material the second year, whether he noticed any correlation between the plots, whether the same blocks were high the second year, and whether the low plots were low the second year, compared with the first.

DR. CUTRIGHT: If we had had the slides on a little bit longer for study, you would have seen it.

METHODS OF BREEDING TRICHOGRAMMA IN CONNECTICUT

By John C. Schread

Abstract

Rearing Angoumois grain moths (*Sitotroga cerealella*) on wheat in 24 separate cages has been more satisfactory than when corn was used. Eight times as many eggs were obtained from wheat moths than from corn moths. Moth extraction is accomplished by a forced draft of air. The parasites are reared in watchglasses in an incubator with the aid of underneath light.

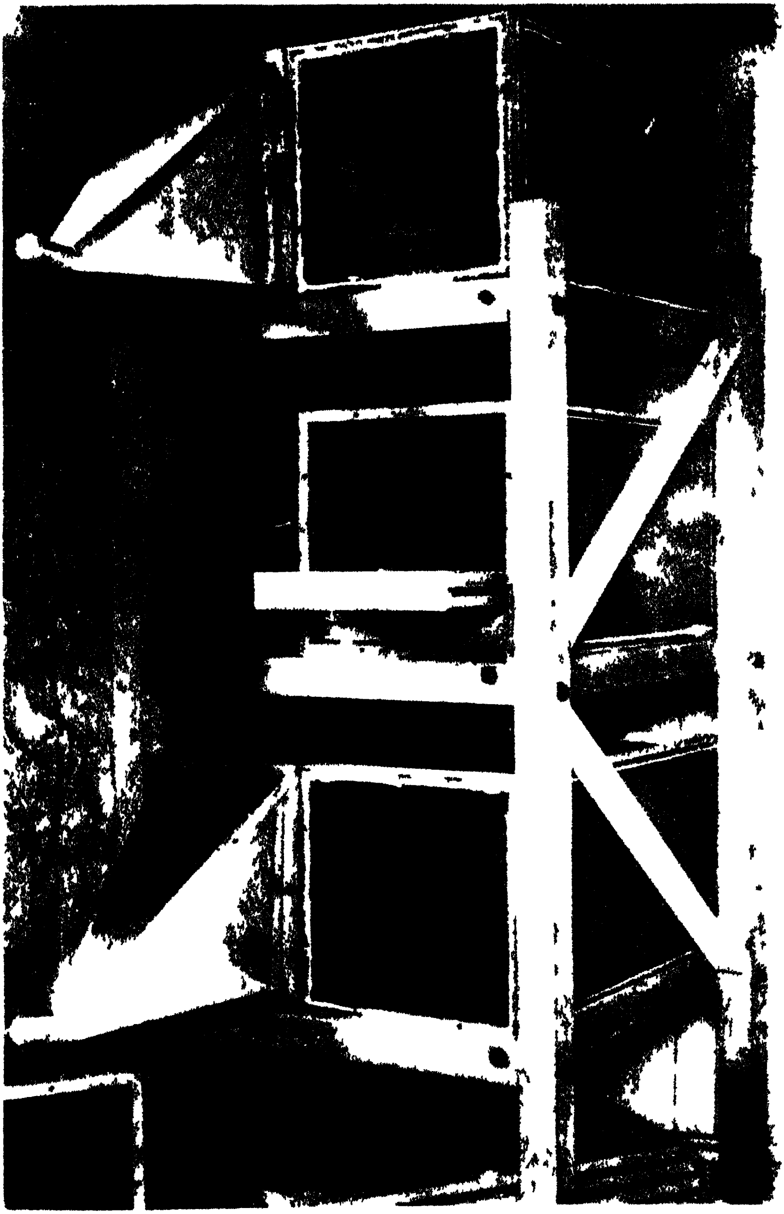
The Angoumois grain moth, a common laboratory host for Trichogramma is reared at the Connecticut Station on red winter wheat. Twenty-four separate cages of the type shown in Plate 17 are employed. Multiplication is very rapid and with our system much greater than when corn is used. For example, a comparative study of wheat and corn in our laboratory indicates that (1) moths begin to emerge sooner from wheat than from corn. (2) the number of moths obtained is far greater in both the first and succeeding generations. (3) there are nearly eight times as many eggs obtained from wheat bred moths because of greater numbers. It has been argued that corn bred moths are larger. This is true, but the eggs laid by moths from wheat are only .007 mm. less in length and .008 mm. less in greatest diameter than eggs obtained from corn bred stock. On the other hand the average number obtained from wheat stock in our experiments was 14 per female, whereas only 13 were obtained from corn bred females. Obviously, much greater egg yields may be expected from wheat than from corn. (Table 1).

Table 1

Extraction	Corn No. moths	Corn No. eggs	Wheat No. moths	Wheat No. eggs
1	1,848	6,283	9,000	90,625
2	1,000	11,595	12,500	65,250
3	920	5,780	3,880	28,143
4	385	2,515	3,500	25,550
5	693	4,342	4,250	30,712
Totals	4,846	30,515	33,130	240,280

Note—6.8 times as many moths from wheat as from corn; 7.8 times as many eggs from wheat moths as from corn moths. Figures arrived at by weight of representative samples.

Grain moth rearing cages used at the Connecticut State Station were modeled, with various improvements, after those formerly used at the Federal Corn Borer Station, Arlington, Mass. Each cage is composed of a rearing compartment 14 inches by 26 inches by 14 inches and an extracting compartment 10 inches by 26 inches by 14 inches. The frames



Carriage with cages for breeding Angoumois grain moths. The trays are filled with wheat and the whole outfit is kept in a room at 80° to 85° F and a very high humidity until the moths emerge. The empty compartment at the left acts as a reservoir where the moths are collected before being blown out through the tunnel.

are 1 inch by ¾ inch white pine with dovetailed corners, glued and reinforced with screws. The bottom and top of each frame is covered on the inside with one-cross bright tin and the back and one side with 30 mesh copper netting tacked on the outside. The compartments are fastened together with 3/16 inch stove bolts. The rearing compartment contains 12 trays with a 5/16 inch aperture between each for moth extraction. The bottom of the trays are of 1/8 inch masonite, and cleats tacked to the underside of the trays prevent them from sliding. The front of the rearing compartment is enclosed by a 30 mesh copper netting door fastened by stove bolts. A funnel made by molding a sheet of tin extends ..m the front of the extracting compartment. The top of the funnel made of celluloid tacked and reinforced with celluloid cement. The te.. are stacked three high on carriages made from 2 ¼ inch white ..astened with 5 inch lag screws and fitted with roller-bearing casters. ..ing the first season of grain moth rearing 4½ pounds of wheat used per tray. However, later experience showed 3½ pounds ..tray to be more satisfactory for with this amount more moths were obtained and there was less unused grain at the end of the season.

TABLE 2. RESULTS OF THREE SEASONS OF ANGOUMOIS GRAIN MOTH REARING

Season	Period of production in months	Bushels of wheat used	Per cent of kernels that produced moths	Seasonal egg production
1930	11	16	73	18,640,000
1931	9	22.9	75	28,698,000
'32	8	17.8	92	38,972,000

Grain moth cages with traps of wheat are sterilized in our rearing room for two days by means of gas stoves at a temperature of 140° F. to 160° F. The rearing room in the basement of the laboratory building is 10 feet by 14½ feet by 9 feet with one window, cement side walls and ..iling, and concrete floor. It is heated by steam pipes and humidified by wetting the floor. After sterilizing, the room is maintained at rearing conditions of 80–85° F. and 60–70 per cent humidity for one week previous to inoculating the wheat with 60,000 grain moth eggs per cage. It is advisable to use unrefrigerated moth eggs as low temperatures destroy the embryo.

Rearing progresses for two months before live moths are extracted. At frequent intervals, however, the dead moths are removed as they are directly responsible for the rapid multiplication of Gamasid mites. Live moths for egg production are extracted directly into oviposition cans which are fastened to the end of the funnels. Oviposition cans are made by replacing the bottom of coffee cans with 30 mesh No. 36 light strainer cloth. A corked hole in the lid of each can serves for the admittance of the moths and three ¼ inch stilts soldered to the lower edge of the can ..for it to stand on during grain moth egg deposition.

Moths are extracted from the cages by means of a strong draft of air from a portable blower. The air is directed from the side of the rearing compartment into the apertures between the trays, thus forcing the moths into the extracting compartment, from whence they are blown by directing the draft of air from the rear of the compartment through the funnel into the oviposition can. Each can receives not more than ½ inch to ¾ inch of moths. Cans of moths are kept on tin trays in an 80° incubator and once in 24 hours for three days they are tapped and shaken gently to dislodge the eggs that do not fall through the 30 mesh strainer cloth onto the trays. Eggs are cleaned of foreign material by blowing a gentle draft of air over their surfaces. Mites may be removed by bouncing the eggs from one moderately rough cardboard to another to which the mites adhere. Eggs for parasitism are fastened with white shellac to one 7/8 inch cardboard disks, 8,000-9,000 eggs per disk. While awaiting parasitism, the egg cards are refrigerated at 38° F. and 60 per cent humidity.

Bevelled Syracuse watch-glasses (2½ inch) ground together in pairs are used as Trichogramma oviposition units. Stock cards of grain moth eggs are divided into sections, inserted in the watch-glasses and placed in a dark incubator. When the parasites begin to emerge the watch-glasses are exposed to light from below in a specially constructed incubator where they complete emergence in a few hours. The egg cards are exposed to the parasites with the egg surface of the card down, in contact with the bottom of the watch-glass where they receive complete illumination. Egg cards are left with the parasites for 3–4 days before they are removed to refrigeration or to the field

The parasite incubator, is constructed of celotex with a four sectioned doubled glass bottom. Electric bulbs thermostatically controlled, provide heat and a pan of water directly below the bulbs conditions the humidity. A six inch fan maintains a constant circulation of air and uniform conditions of 80° F. and 70 per cent humidity through the incubator. The incubator is raised on four 16-inch legs allowing ample space below for eight 25 W. daylight bulbs, which provide sufficient light for the parasites. Each of the four glass sections in the bottom of the incubator accommodates 24 watch-glasses. Four extra shelves placed above these, doubles the area, thus making it possible to rear over one and one-half million Trichogramma at one time.

TABLE 3. YEARLY TRICHOGRAMMA PRODUCTION

1930	16,216,000
1931	20,768,000
1932	22,320,000

ECONOMIC STATUS OF THE JAPANESE BEETLE IN 1932

By L. H. Worthley and C. W. Stockwell, *Bureau of Plant Quarantine, U. S. Department of Agriculture, South Norwalk, Conn.*

Abstract

In 1932 the Japanese beetle (*Popillia japonica*) probably caused greater destruction of fruit and produce crops than in any year since its discovery in 1916. A larger number of classified nurseries disclosed infestations than during 1931. Traps distributed in cities and towns outside known infested territory resulted in discovery of a large number of first record infestations at points more remote from the densely infested zone than any heretofore found infested. This does not necessarily indicate a greater spread of the insect in 1932 than in any previous year, but demonstrates that scouting with traps is more efficient than visual scouting by temporarily employed scouts. Survey of southern New Jersey, southeastern Pennsylvania and northern Delaware sections most heavily infested by the beetle disclosed that from 75 to 100 per cent defoliation of preferred food plants took place over an area of 1,647 square miles, that foliage damage of from 50 to 75 per cent was evident in 1,378 square miles, and that evidence of at least 25 per cent foliage injury was observed over an additional area of 1,353 square miles.

Comparative observations made in sections densely infested with the Japanese beetle indicate that the insect this year probably caused greater destruction of fruit and produce crops than in any year since its original discovery in 1916. Increase in the extent of infestation in the zones of dense beetle population is also reflected in the increased number of classified nurseries on which, or within close proximity to which, Japanese beetles were found. In 1931 beetles were found on or near the premises of 126 nursery establishments. Similar initial infestations were discovered during the past summer at 163 classified nursery establishments. For the past several years adult beetles have been known to cause considerable commercial damage to cut flowers grown throughout the winter and spring months in greenhouses in the Philadelphia zone. During the past winter and spring, these adults were found in greater numbers than in previous years. A few instances have also been noted of heavy concentrations of larvae in uncertified nursery plots destroying evergreen stock, thus compelling the poisoning with arsenate of lead of the nursery block to protect the stock. Such treatment has been entirely for plant protection rather than in compliance with quarantine requirements. Beetle population increases were sufficient in Long Island and Westchester County, N. Y., and the northeastern counties of New Jersey to arouse public interest and require the attention of city foresters and park departments in combating the insect Adult beetle flights of noticeable proportions took place in sections of Wilmington, Dela. and Harrisburg, Penna. Beetle infestation in the

principal blueberry growing section of New Jersey was such that the grower's association on their own initiative this year fumigated most of their production offered for sale during flight of the adult beetle. Through the County Agent of Burlington County, N. J. was reported for the first time heavy beetle damage to soybeans, requiring early harvesting of the crop to prevent entire destruction of the stand.

This season's field inspection work outside infested territory marked a new departure in the Department's search for possible spread of the insect. Instead of organizing temporarily employed and hurriedly trained men into crews and assigning them to scout a large number of cities and towns, all field work to determine the present scope of the beetle outside the 51,339 square miles now under regulation was performed with traps developed at the Japanese Beetle Research Laboratory of the Bureau of Entomology. An initial supply of 35,000 traps was supplemented by a purchase of 21,000 additional traps. Bait in the quantity necessary for baiting the entire supply of traps was mixed at the South Norwalk headquarters early last spring. All used traps were reconditioned and repainted before being packed in cartons, each containing one dozen traps, and shipped in carload lots to trapping locations or to central points for redistribution to nearby cities. Trapping activities began on April 15, when traps were placed in Miami, Florida. Trap distribution in three Florida cities was completed by May 2. Supervisors then transferred to Georgia where they directed locally employed trap inspectors in establishing trap routes. Organization of the trapping program thus progressed northward as the anticipated beetle emergence dates warranted trap placement. Spread determination by means of traps was under way during May in Georgia and North and South Carolina. Beginning in June, traps were placed in selected cities in Virginia, Maryland, West Virginia and Ohio. During July trap distribution began in Pennsylvania, New York, Massachusetts, New Hampshire and Michigan. Final placement of traps was made in Vermont and Maine during August. In all, 45,721 traps were used in determining absence or presence of beetles in non-regulated territory. The balance of the project's supply was used in beetle population control measures in sparsely infested sections of the quarantined zone. Traps were operated for periods varying from 30 to 60 days in three cities each in Florida and Georgia, four cities in South Carolina, five cities in North Carolina, and three cities in West Virginia. In the unregulated portions of states already partially quarantined, traps were in operation in 32 towns and cities in Virginia, 35 communities in Maryland, 50 localities in Pennsylvania, 43 localities in New York, and in 62

Massachusetts towns and cities. The New England trapping program was carried on in six cities each in Maine, New Hampshire and Vermont. In the East North Central States, traps were placed in 13 Ohio cities, in Detroit, Mich., and Richmond, Ind. Selection of these 273 towns and cities as sites for trapping activities was made on the basis of their ranking as transportation centers, as possible destination points of illegally transported infested produce or nursery stock, or as population centers affording favorable environments for establishment of a few beetles accidentally carried from the zone of heavy infestation.

First-record trap catches of beetles have been made outside the regulated area this season at Florence, S C.; Durham, Raleigh and Winston-Salem, N. C ; 17 communities in Virginia, Charles Town, Martinsburg, and Wheeling, W. Va ; Canton, Steubenville, and Zanesville, Ohio; Detroit, Mich.; 21 locations in Maryland; 27 towns and cities in Pennsylvania; 31 communities in Massachusetts, 21 towns and cities in New York; Concord, Dover, Keene, Manchester, Portsmouth and West Lebanon, N. H.; Bellows Falls, Brattleboro, Rutland, and White River Junction, Vt.; and Augusta, Kennebunk, and Portland, Me. In all, 3658 beetles have been collected in the 143 towns and cities disclosing infestations in non-regulated territory; 117 of these infestations have been discovered in states already partially quarantined. Trapping was with negative results in Florida, Georgia and Indiana. Freedom from beetle infestation was also indicated in 123 cities scattered throughout the other states trapped

Discovery of such a large number of first-record infestations does not necessarily indicate a greater spread in 1932 than in any previous year but may be attributed to the increased efficiency of detecting by means of traps the presence of even a few adult beetles in a community isolated from the infested zone. Distribution of from 100 to 400 traps in a community over a period of from one to two months furnishes a more positive index than previously has been available of beetle conditions in a specific city. Surveys by scouts have in past years permitted usually only a single survey of individual premises. Although it is possible to cover by means of scouts much wider territory, the likelihood of finding any beetles present in a limited number of communities is much greater when traps are maintained over a minimum 30-day period.

Beetles were recovered in sufficient numbers in 52 cities to assume the existence of established infestations of one or more year's standing. Fewer than 10 beetles were collected at the remaining 91 infestations. The locations in which these latter beetles were caught, the dates on which they were trapped, and the accompanying conditions of adult flight

in the densely infested zone point to the probability that many of these smaller finds are of the current year's spread. Very likely similar movement of beetles in small numbers has taken place over the period of years since the Philadelphia section has been so densely infested. Adult mortality and the remote chance of only a few scattered adult beetles perpetuating themselves have kept infestation establishment at a minimum. However, some few beetles have succeeded in gaining a foothold at isolated points, but visual scouting has previously failed to disclose the limited infestations. Now for the first time traps are catching beetles which, in probably 75% of the cities trapped, would under normal scouting conditions escape detection

It has not been possible at any of the isolated infestations to determine the exact manner by which the beetles were transported from an infestation center. Indications as to the methods by which this spread has taken place are somewhat varied. Some of the infestations have been found in close proximity to freight or passenger terminals, indicating carriage of the insect in or on freight cars or passenger coaches Other infestations in residential districts may trace back to adult beetles accidentally carried by private automobile or truck from the heavily infested area, or by means of grubs in nursery stock or adults in farm products shipped by common carriers or moved by automobile in ignorance of the quarantine restrictions.

Initial steps were taken during the past year in a number of rather extensive control measures within the infested area. A demonstration was staged in Philadelphia to determine the feasibility of large scale beetle population reduction by means of traps placed on lead arsenate poisoned soil. Six vacant lots were used in this demonstration. In the fall of last year, the lots were plowed and harrowed, and lead arsenate applied at the rate of 1500 lbs. per acre. Smartweed, a favored non-economic food plant of the beetle, was then seeded on the plots as a further attractant to the insect. During the period of adult flight, 476 traps were distributed among the six plots. Catches of over 13½ million, or more than 2800 lbs. of beetles were made. Destruction of many larvae hatched on the plots is also assured by the poisoned soil. An extensive trapping program under State auspices was also carried on in the most densely infested section of southern New Jersey. In the farming district comprising approximately 75 square miles surrounding Elmer, N. J., 2100 State-owned traps were distributed to local farmers by Mr. Edgar G. Rex of the New Jersey Department of Agriculture. Mr. Rex's report indicates that throughout the adult season a total of approximately 55¼ tons, or the equivalent of 804 fifty-gallon barrels of beetles were caught

and destroyed in Salem county. Cooperative trapping work with a number of states was also carried on within the regulated sections of Connecticut, Pennsylvania, Delaware, Maryland and Virginia. Numerous community spraying campaigns in heavily infested cities were again repeated this year. In addition, considerable spraying work was performed by private contractors in the environs of Philadelphia. Beetle collecting contests were also held by a number of garden clubs or local officials in newly infested territory. Application of lead arsenate in large quantities to lawns on infested estates in Philadelphia suburbs has come to be a common practice.

A number of now quarantined isolated infestations discovered last year and subsequently treated with arsenate of lead were again trapped this summer. Finds in Little Falls, N. Y., where treatments were made in November, 1931, increased from 7 beetles last year to 23 beetles caught during the past trapping season. At Erie, Penna., trapping activities this year were supplemented with a frequently applied attractive poisonous spray. Only a slight increase in the Erie infestation was detected, 282 beetles having been trapped this season as compared to a total of 163 caught in 1931.

Extermination of an infestation of four beetles discovered during 1931 in Charleston, S. C. is indicated by negative results of trapping activities in that city this year. Premises surrounding the Charleston infestation were treated with lead arsenate during November, 1931. At Watkins Glen, N. Y., where similar treatments were applied to premises on which were found three beetles last year, only a single specimen was trapped this year. Finds of 15 beetles in Richmond, Va. during 1931 increased to 88 this year.

Road patrol operations began this year in April with the establishment of vehicular inspection posts in Virginia, Maryland, Pennsylvania and New York. Similar inspection work began in Massachusetts early in May. Posts were continued in Massachusetts and New York until the middle of June. Virginia, Maryland and Pennsylvania stations were continued until late in November. At the peak of the spring movement of quarantined articles there were 53 border patrols in operation for varying daily periods. During the present year 1,565,391 vehicles have been examined by the inspectors on guard at the boundary of the regulated zone. Contraband has been intercepted in 17,214 vehicles. From the uncertified material surrendered at the road stations 250 beetles in the adult, larval or pupal stage have been removed. Single shipments containing as many as 22 grubs were among the interceptions.

Reduction in the number of classes of farm products under restriction

and enlargement of the New York regulated area, effective January 1, 1932, considerably curtailed the amount of quarantined farm products and cut flowers shipped under certification. Despite the reduced quantity of articles offered for inspection during the seasonal quarantine, approximately 45,500 shipments of these articles moved from the regulated area under certification. Inspections were made at 67 inspection centers conveniently scattered throughout the regulated zone; 1843 beetles were removed from articles presented for inspection. Shipments of certified farm produce and cut flowers during the past season moved to all the Southern and New England States, to many midwestern states, and in some instances as far as California Conditions of infestation in southern New Jersey and in the vicinity of Baltimore necessitated considerable additional inspection of farm crops previously certified on the basis of freedom from infestation of the farming district in which it was grown Spread of the insect to the principal sand pits in New Jersey enlarged the territory from which during adult flight quarantined sand may be shipped only after fumigation

Observations were made for seven weeks during the past summer to determine the extent of the sections in southern New Jersey, southeastern Pennsylvania, and northern Delaware in which Japanese beetle defoliation or partial defoliation of favored food plants was conspicuous and readily observable from an automobile proceeding at a moderate rate of speed Defoliation to the extent of between 75 and 100 per cent was obvious over an area of 1,647 square miles. Damage of from 50 to 75 per cent was evident in 1,378 square miles Evidence of at least 25 per cent foliage injury was observed over an additional area of 1,353 square miles A total of 4,378 square miles was found infested to the degrees noted Among the plants wholly or partially defoliated were apples, peaches, cherries, plums, quinces, lindens, willows, larch, young Norway maples, sassafras, horse chestnuts, grapes, raspberries, blueberries, blackberries, field and sugar corn, certain other vegetables, and a number of ornamental plants. In this densely infested section, heavy concentrations of grubs also destroyed or badly injured sod in lawns and golf courses.

PRELIMINARY TESTS WITH LIQUID BAIT IN JAPANESE BEETLE TRAPS[1]

By F. W. Metzger, *Associate Entomologist, U. S. Bureau of Entomology*

Abstract

The bait for Japanese beetle (*Popillia japonica*) traps as usually prepared loses its effectiveness upon exposure in the field. In an attempt to devise a method of maintaining the attractiveness of the geraniol and eugenol over a considerable period of time, these substances were vaporized by means of wicks of various lengths placed in small bottles containing the attractive agents. The results indicated that when wicks of a certain size were used in traps of two types, more beetles were captured than in check traps containing the bran-molasses mixture with the attractants added.

The most satisfactory bait generally used in Japanese beetle traps consists of a mixture of geraniol, eugenol, bran, molasses, glycerine, and water[2] Geraniol and eugenol are, however, the substances which attract beetles to the traps. The other materials are used as a carrier for the attractants; that is, to hold moisture and facilitate mixing. This bait, although very effective in drawing beetles to traps, is bulky and, upon exposure in the field, gradually decreases in attractive power as the geraniol and eugenol are vaporized

In an effort to devise a method of exposure of the geraniol and eugenol in the traps which would make them of constant maximum attractiveness to the beetle over a period of several weeks, these substances were vaporized by means of a wick inserted in a bottle containing the attractants[3]—a method that had previously been considered by Van Leeuwen in 1928. Numerous tests were conducted during the summer of 1932, the wicks being employed in the trap where the bait container is located in the trap cylinder (Pl. 18, fig. 1) and also in a new type of trap where the cylinder is eliminated, the bait being placed in a container situated in the trap baffle (Pl. 18, fig. 2).

The wick employed in the tests is of the type used in an ordinary alcohol lamp. It is 3/16 to ¼ inch in diameter, of cotton, the inner fibres, 12 in number, running length-wise and covered on the outside by a woven cotton sheath. This was inserted through a cork into a 1-ounce bottle, and the portion of the wick within the bottle was without a sheath. Geraniol was used at the usual rate of 10 parts to one part of

[1]Contribution No. 112 from the Japanese Beetle Laboratory, Moorestown, N. J,

[2]Metzger, F. W. Trapping the Japanese beetle. U. S. Dept. Agr. Misc. Pub. 147. 8 pp., illus. 1932.

[3]The writer desires to express his appreciation of assistance rendered by W. E. Fleming, E. G. Rex, and W. W. Maines.

eugenol, the bottle being filled at the beginning of the test. Any liquid remaining at the close of the experiment was suitable for future use.

The standard method of testing different types of traps and bait was employed. Each trap with liquid bait was located 2½ feet from the check trap containing standard bait. The number of beetles captured in each test represents the total from five such pairs of traps with an interval of 10 feet between pairs.

LIQUID BAIT IN STANDARD TRAPS.—Wicks of the following lengths were used in this series of tests: 4 inches sheathed, 2 inches sheathed, and 1 inch with and without sheath. The wick measurement in each instance represents the actual length exposed and does not include the length contained in the bottle. Longer wicks were not employed because there was no convenient way by which they could be supported in the trap cylinder. Without support, wicks of this type toppled over, came in contact with the bottom of the container, and siphoned off the contents of the bottle.

The results of these tests are summarized in Table 1.

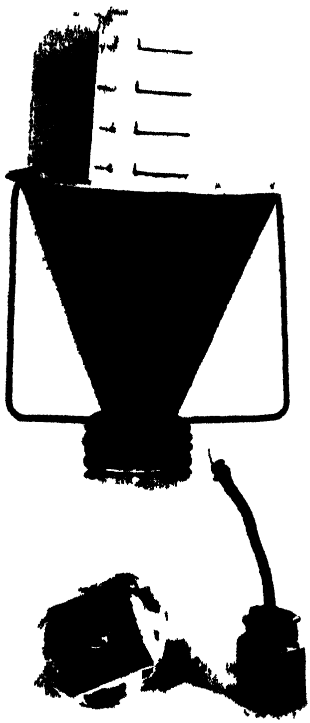
TABLE 1. SUMMARY OF TESTS WITH LIQUID BAIT IN STANDARD TRAPS

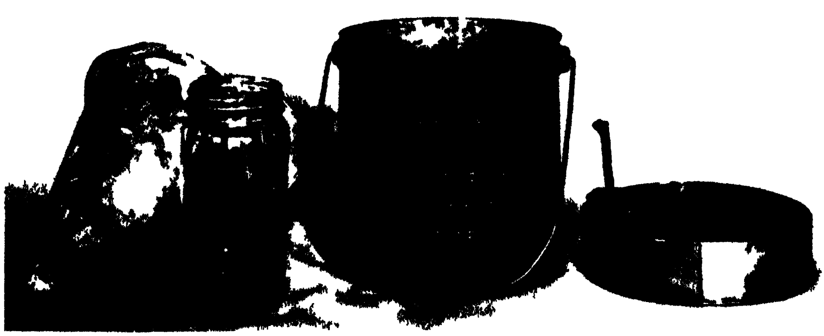
Wick length	Experimental traps (liquid bait) No. beetles	Check traps (standard moist bait) No. beetles	Per cent increase or decrease, experimental over check traps
4 in. sheathed	55,770	43,975	+26.8
2 in. sheathed	38,965	36,414	+ 7.0
1 in. no sheath	75,620	83,575	— 9.5
1 in. sheathed	12,750	14,300	—10.8

A study of the above table shows that the greatest increase in beetle catch over that from the check traps occurred when a 4-inch wick was employed, the difference in favor of the liquid bait being 26.8 per cent. The attractants were vaporized at an average rate of 2.2 grams per trap per day during 8 days in the field When a 2-inch wick was used an insignificant increase over the checks resulted, but in this test geraniol and eugenol were vaporized at a slower rate, the amount being 1.07 grams per trap per day over a 31-day period. In both tests with the 1-inch wicks there was a decrease from the checks in the number of beetles caught over a similar period and the attractants were volatilized more slowly than with the longer wicks.

LIQUID BAIT IN TRAPS WITH BAIT CONTAINERS LOCATED IN THE BAFFLE.—The traps used in this test are representatives of a group wherein the cylinder was eliminated and the bait located in a 6-inch shuttered container placed in the baffle. This series of tests illustrates the superiority of the liquid bait over the standard bait when used in traps of this general type. Wicks were employed in the following

Plate 18





Standard trap showing arrangement for liquid bait above

Trap without cylinder, with $7\frac{1}{2}$ inch funnel and with shuttered bait container located in baffle below

lengths: 5 inches sheathed, 3 inches unsheathed, and 1 inch unsheathed. The 5-inch length was attached to a hook located at the top of the bait container, but the other lengths were placed in the receptacle unsupported. All tests were of 30 days duration.

As the check traps had bait in the cylinders, it was necessary to conduct one test where each type was similarly baited in order to first calibrate the normal difference between the two types of traps. The data obtained from these tests are summarized in Table 2.

TABLE 2. SUMMARY OF TESTS WITH LIQUID BAIT IN TRAPS WITHOUT CYLINDERS

Wick length	Experimental traps (bait in baffles) No. beetles	Check traps (standard bait in cylinders) No. beetles	Per cent increase or decrease, experimental over check traps
5 in. sheathed	58,430	44,700	+30.7
3 in. no sheath	86,380	76,030	+13.6
1 in. no sheath	22,800	28,900	—21.1
Standard bait	66,928	56,963	+17.5

As indicated in the above table, the increase over the check traps when 5-inch sheathed wicks were employed was 30.7 per cent. Standard bait used in this type of trap gave an increase of 17.5 per cent over the check traps, which leaves a net increase of 13.2 per cent in favor of the liquid bait over the bran-molasses mixture. During the 30-day period of the test the average amount of geraniol and eugenol vaporized per trap per day from the 5-inch wicks in the experimental traps was 0.55 gram, as compared with 1.07 grams from the 2-inch wick in the cylindrical trap in the series mentioned above, while the difference in the number of beetles captured was 6.6 per cent in favor of the former. The greater amount of the attractants vaporized by the shorter wick is accounted for by the fact that the temperature inside the cylinder was several degrees higher than that in the shuttered container.

COST OF LIQUID BAIT.—In 1932 the Japanese Beetle Laboratory prepared 3,000 baitings for standard traps at a cost of \$.08758 each, including labor.[4] A larger quantity probably could have been made at a lower cost. In order to obtain the most effective results, this bait should be changed at bi-weekly intervals, making the cost \$.17516 for a four-week period. During a like interval a 5-inch wick in a shutter-type container dispensed 16 grams of geraniol and eugenol at a cost of approximately \$.05. In the traps where the bait was placed in the cylinders the average consumption was 1.07 grams per day, or 29.96 grams for 28 days, which amounted to \$.1056. A 4-inch wick used 61.6 grams, and

[4]The cost of the various bait ingredients were as follows; geraniol (87 per cent pure, aldehyde free, sp. gr. .879 to .882 at 20°C.) \$1.50 lb.; eugenol, U. S. P., \$2 lb.; molasses (good table grade) \$.47 gal.; glycerine, C. P., \$.15 lb.; bran \$.0125 lb.

this amount of the attractants cost \$.229, or considerably more than the regular bait for a similar period.

The wicking is comparatively inexpensive, but would probably have to be replaced each year. Bottles and corks, while involving a considerable initial expenditure, would probably last over a period of several seasons, making the yearly cost very small.

The results from the tests with liquid bait appear promising. There are, however, several convenient methods of dispensing geraniol and eugenol which could not be tested because of the brevity of the beetle season. Further investigation of this problem is contemplated

MR. FELT: I should like to inquire as to the probability of the bait trap being a successful method of controlling the Japanese beetle in badly infested areas.

MR. METZGER: That is rather a difficult question to answer. We realize at the present time the trap attracts more beetles that it catches, and whether we will ever be able to develop a trap which will capture all beetles attracted to it is a problem.

I might state we have made definite strides forward every year since we have been working with traps, but there is one consideration which I think very important, and that is that I do not believe we could ever get enough people interested in using traps until we get a trap which is nearly perfect. The situation at the present time is that a person in one block will use a trap and he will capture a lot of beetles, probably more than he would have ordinarily. If everyone in that particular town had a trap in his yard there would be no focal point of attraction, and everyone would probably have the same infestation as if there were no traps present. I think if in a community every individual living there put out a trap, the number of beetles caught would be tremendous, but whether or not we would be able to clean up the infestation is a problem. Traps on a poisoned sod make an excellent combination

MR. HERRICK: Has any attempt ever been made to determine whether the beetles had deposited eggs.

MR. METZGER: Some eggs are probably laid, but I examined a considerable number of beetles at the end of last season, from the 25th of August to the 1st of September. A large number of them still had considerable egg material left, and a number of eggs which were apparently ready to be deposited.

RELATION OF TEMPERATURE TO THE DEVELOPMENT OF THE PLUM CURCULIO IN APPLES[1]

By W. D. Whitcomb, *Massachusetts Agricultural Experiment Station*

ABSTRACT

The rate of development of the immature stages of the plum curculio (*Conotrachelus nenuphar*) increases with each increase in temperature above 55° F. The number of punctures by adults in unsprayed apples also increases with the temperature but less rapidly than the number of eggs deposited. When confined with apples sprayed with lead arsenate, the number of days which the beetles live and the number of punctures which they make before death decreases with each increase in temperature and each increase in the concentration of lead arsenate. By applying sprays or dusts just before the first period of high temperatures following the petal fall stage, fruit growers have decreased injury by this insect 11 to 20 per cent, compared to less timely applications.

The plum curculio is one of the most injurious insect pests of apples in Massachusetts, not only causing unsightly scars which depreciate the value of harvested fruit but also causing all apples in which a larva develops to drop prematurely, thus decreasing the size of the crop. In laboratory experiments, the beetles were readily killed by puncturing fruit sprayed with lead arsenate, while feeding and ovipositing, but the results from the use of this insecticide in the orchard were extremely variable, being entirely unsatisfactory in many cases. These failures to control with arsenical sprays were apparently due to faulty timing of applications in relation to the activity of the insect. When various stages of the plum curculio were confined at constant temperatures, it soon became evident that temperature exerted a strong influence on the development and activity of this insect and was an important factor in timing the application of control measures.

Development of Immature Stages.—The average time required for development of the immature stages decreased with each increase of 10° F. in temperature. The greatest decrease occurred between 65° and 75° F., and the least between 75° and 85° F. In the individual records there

Table 1. Development of Immature Stages of the Plum Curculio at Constant Temperatures, Waltham, Mass., 1932

Temperature Fahrenheit	Incubation of eggs average days	Feeding of larva average days	Larva, pupa and adult in soil average days
55°	*Development incomplete*		
65°	12.72	27.00	36.93
75°	5.31	12.70	23.83
85°	3.95	11.85	20.91
Insectary	7.1	16.09	30.54

*Exceptions discussed in text.

[1]Contribution No. 159 of the Massachusetts Agricultural Experiment Station.

is evidence that the development is slightly checked at 85° F., indicating that the optimum temperature is near 80° F. At 55° F. one larva hatched after 53 days but did not leave the eggshell and three partly matured larvae were found in apples after 70 days, but did not leave the fruit. All other specimens died before the final observations were made, indicating that this temperature is very close to the minimum for development.

ACTIVITY OF THE BEETLES.—More than 80 per cent of the activity of the adults takes place in the first 30 days after mating; this period in 1932 extending from May 28 to June 26. During this time, the average number of punctures made in the apples decreased in each successive period of 10 days. However, the proportion of egg punctures to feeding punctures was about 5 per cent greater in the second 10-day period, and throughout the oviposition period this ratio increased with each increase in temperature ranging from about 30 per cent at 55° to 55 per cent at 85° F.

TOTAL PUNCTURES.—The effect of temperature on the number of punctures which the beetles make under controlled conditions is shown in Table 2. This activity based on observations of 10 pairs of beetles increases in the approximate ratio of 1:3:5:6 with each increase of 10° in temperature from 55° to 85° F.

TABLE 2. NUMBER OF PUNCTURES IN APPLES IN 30 DAYS BY 10 PAIRS OF PLUM CURCULIOS AT CONSTANT TEMPERATURES, WALTHAM, MASSACHUSETTS, 1932

Temperature Fahrenheit	Number of punctures	Average number of punctures per beetle
55°	534	26.7
65°	1,740	87.0
75°	2,668	133.4
85°	3,324	166.2

OVIPOSITION.—Increasing temperatures apparently stimulate oviposition more than they do feeding. As is shown in Table 3, the average number of eggs laid by 10 mated female beetles increased in the approximate ratio of 1:5:9:12, with each increase of 10° from 55° to 85° F.

TABLE 3. OVIPOSITION BY 10 MATED FEMALE CURCULIOS AT CONSTANT AND OUTDOOR TEMPERATURES, WALTHAM, MASSACHUSETTS, 1932

Temperature	Average number of eggs per beetle	Maximum number of eggs per beetle	Maximum number of eggs per beetle per day
55°	16.1	41	4
65°	74.2	169	14
75°	139.7	240	20
85°	197.3	332	22
Insectary	205.0	345	19

It is interesting to note that at each of the controlled temperatures as well as at the variable normal outdoor temperature the last egg was laid from July 22 to July 26, 56 to 60 days after the experiments were started.

Length of Life.—Under experimental conditions, the length of life of individual curculios has been very variable. Although oviposition ceases at 60 days, and feeding is very intermittent after that time, at least one individual at each temperature lived over 100 days after mating. As shown in Table 4, the average life of plum curculio beetles tends to increase with the decrease in temperature.

Table 4. Average Number of Days Which Beetles Lived After Mating at Constant Temperatures, Waltham, Massachusetts, 1932

Temperature Fahrenheit	Average length of life in days Males	Females	Both sexes
55°	94.8	112.0	103.8
65°	81.6	75.6	78.6
75°	62.2	50.2	56.2
85°	60.2	55.6	58.0

Poisoned Fruit.—When confined at constant temperatures with fruit sprayed with lead arsenate, the average number of days which the beetles lived while feeding on the poisoned apples tends to decrease with each increase in temperature, and with each increase in the concentration of lead arsenate, from 3 pounds to 6 pounds in 100 gallons of water. At 55° F., and when lead arsenate is used at the rate of 3 pounds in 100 gallons, there have been a few individuals which lived more than twice as long as the average, thus making the results inconsistent and indicating that these conditions are too near the border line of effectiveness to insure reliable deductions. It is evident that the time required for the poison to kill depends on the amount of feeding and the promptness with which it begins, both of these factors increasing directly with the temperature. In some of the observations there has been an indication that lead arsenate at the rate of 6 pounds in 100 gallons of water is repellent to the beetles, causing them to delay feeding temporarily and thus increase their length of life.

Table 5. Average Length of Life of Plum Curculio Beetles at Constant Temperatures When Feeding on Fruit Sprayed With Lead Arsenate, Waltham, Massachusetts, 1932

Concentration of lead arsenate	Average number of days alive 55°F.	65°F.	75°F.	85°F.
3 lbs.–100 gals.	6.8	8.6	11.3	11.6
4 lbs.–100 gals.	7.0	4.8	5.8	3.9
5 lbs.–100 gals.	4.4	4.3	3.0	2.6
6 lbs.–100 gals.	3.9	3.5	2.1	2.4

The number of punctures made in poisoned fruit is extremely variable, especially at the lower temperatures and with the smaller amounts of poison, and is apparently related to the condition of the individual. The majority of the punctures were made in the first two days after the beetles received the sprayed apples. There is little indication as to how

many punctures are necessary to obtain a lethal dose of poison, but in spite of several inconsistencies the averages shown in Table 6 indicate a tendency for the number of punctures to decrease with increases in temperature and in concentration of the lead arsenate. The majority of these punctures are feeding punctures.

TABLE 6. AVERAGE NUMBER OF PUNCTURES PER BEETLE WHEN FEEDING AT CONSTANT TEMPERATURES ON FRUIT SPRAYED WITH LEAD ARSENATE, WALTHAM, MASSACHUSETTS, 1932

Concentration of lead arsenate	Average number of punctures per beetle 55°F.	65°F.	75°F.	85°F.
3 lbs.–100 gals.	1.9	7.8	4.3	10.1
4 lbs.- 100 gals.	4.7	4.7	4.5	4.2
5 lbs.–100 gals.	1.7	3.3	4.0	4.4
6 lbs.–100 gals.	2.6	2.4	2.3	2.1

Feeding on poisoned fruit results in a much greater decrease in oviposition than it does in total activity. Among 80 female curculios, 63 or 78.75 per cent laid only 2 eggs or less before death, and 34 or 42.5 per cent died without laying eggs, indicating that many of them take poison into their system while crawling over the surface of the sprayed fruit seeking a suitable place to puncture. Records also show that in one-half of the sixteen series under observation, the only eggs laid by females in poisoned fruit were deposited on the first day that sprayed apples were available.

ORCHARD APPLICATION.—Hibernating plum curculio beetles do not appear in the orchard in consequential numbers until after the petals have fallen and injury to the fruit before it reaches about one-half inch in diameter is insignificant. Therefore, the critical period occurs during the first continued spell of warm weather after the proper time for the calyx or petal-fall application.

In 1930 this critical period extended from June 1 to June 7 inclusive, with a maximum temperature of 94° F. on June 5. The stimulated activity from high temperatures was well advanced by June 2, making applications after that date less effective. Records from twenty-nine orchards in Worcester County, Massachusetts, as summarized in Table 7 show that the average injury by the plum curculio to harvested apples sprayed on or before June 2 was 11 per cent less in the McIntosh variety

TABLE 7. PERCENTAGE OF HARVESTED APPLES INJURED BY THE PLUM CURCULIO, WORCESTER COUNTY, MASSACHUSETTS, 1930

Time of application	Variety	Number of orchards	Injury per cent Maximum	Minimum	Average
May 28 to June 2.....	McIntosh	10	10.0	0.47	3.79
	Baldwin	4	4.9	1.7	3.55
June 3 to 7............	McIntosh	7	64.5	0.36	14.82
	Baldwin	8	34.6	4.2	17.28

and 14 per cent less in the Baldwin variety than where the spray was applied on June 3 or later.

In 1931 the critical period of high temperatures extended from May 26 to June 1. Curculio activity was well advanced by May 28, making it imperative that the most timely applications be made on or before that date. In Table 8 the records of thirty-eight orchards show that the average injury in orchards sprayed on or before May 28 was 14 per cent less in the McIntosh variety and 20 per cent less in the Baldwin than in those orchards sprayed after May 28.

TABLE 8. PERCENTAGE OF HARVESTED FRUIT INJURED BY THE PLUM CURCULIO, WORCESTER COUNTY, MASSACHUSETTS, 1931

Time of application	Variety	Number of orchards	Injury per cent Maximum	Minimum	Average
May 26 to 28	McIntosh	6	6.8	0.7	4.33
	Baldwin	6	4.2	1.2	3.0
May 29 - June 6	McIntosh	16	57.6	12.6	24.85
	Baldwin	10	39.7	7.3	17.88

Through the cooperation of the Weather Bureau, and the experience from several years of observations, the critical periods of curculio activity in relation to temperature have been predicted with considerable success and the information has been satisfactorily broadcasted over the radio and through the County Extension Services.

RECOMMENDATIONS

Based on the studies and observations reported in this paper, the following recommendations for control of the plum curculio in apples with insecticides have been adopted in Massachusetts:

After the blossom petals have fallen, apply a special spray or dust in the first period of warm weather when the maximum temperature reaches 75° F. or higher and promises to continue for two or more successive days. Use 4 or 5 pounds of lead arsenate in each 100 gallons of spray, preferably with the addition of 1 pint of fish oil or linseed oil as a spreader or sticker. Except in severe infestations 85 15 sulfur-lead arsenate dust can be substituted for the spray.

Where there are two distinct periods of high temperature within 15 days after the petal fall, apply a spray or dust in each period, using the same materials and determining the time for the second application by the same temperature requirements as before.

On scab susceptible varieties, or where the addition of a fungicide is desirable for any reason, liquid lime-sulfur or a similar material can be added to the spray without danger of greatly decreasing the efficiency of the mixture.

FURTHER STUDIES ON THE CONTROL OF THE APPLE CURCULIO IN THE CHAMPLAIN VALLEY

By O. H. Hammer, *N. Y. State Agr. Exp. Station, Geneva, N. Y.*

Abstract

Additional life history studies of *Tachypterellus quadrigibbus* were made. Results obtained by collecting the June drops in 1931 are discussed. In experimental plats partial control was again secured by properly timed heavy applications of lead arsenate sprays.

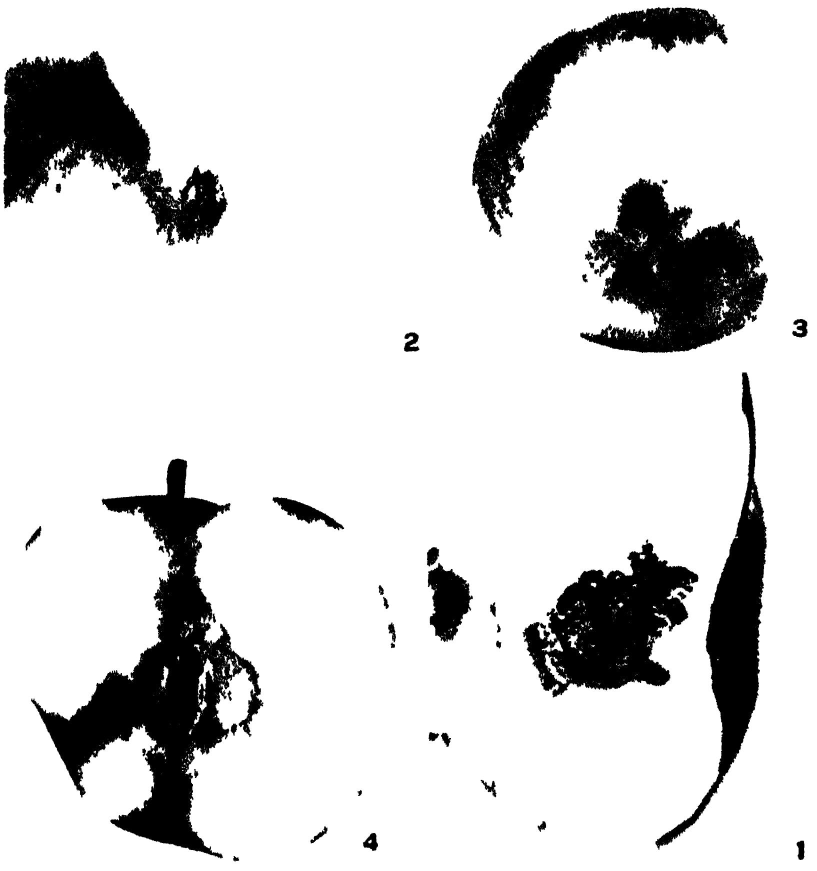
What follows is a continuation of studies reported in this journal Vol. 25; 569–573, 1932.

Life History Notes.—During the spring of 1932 emergence cages were placed over naturally infested overwintering quarters. Regular inspections of these cages showed that the hibernating beetles became active shortly before the middle of May. The first beetles were collected from the cages on May 10th, the greatest number on May 25th, and the last on June 11th. The first eggs were deposited about June 1, and the new generation curculios began to emerge from June drops on July 21. Each of the phases of development of this insect during 1932 was a few days later than in 1931.

It was pointed out in my former paper that in certain cases a considerable number of beetles emerge from mummified apples which cling to the trees. At the same time attention was called to the fact that in many instances curculios continued their development within growing apples. Both these phonomena were again observed in 1932 and a great number of beetles were found in each situation. At picking time a large number of apples were noted to have emergence holes in them. (A typical example is shown in Fig. 3, P1. 19). A great number of McIntosh apples were cut open at picking time and many of them were found to contain living adult curculios. Some of these beetles had eaten a tunnel from their pupal chambers to the surface of the apples and had only to break the skin to escape. In other cases the beetles would probably never have escaped, since they were feeding toward the core rather than toward the surface of the apples. A curculio in the act of emerging from a mature fruit is shown in Fig. 2, Pl. 19.

A record of the emergence of new generation beetles from the June drops is given in Table 1. Cage 1 presents the emergence record from June drops collected before July 12th. Cage 2 shows the emergence from fruits which fell after July 12th and were collected on July 19th. The record of cage 2 has an important bearing on control and is discussed later.

Plate 19



1 Adult beetle in mature apple 2 Beetle emerging from mature apple 3 Emergence hole made about [illegible] 4 Pupal chamber and tunnel to exterior made by emerging curculio

HIBERNATION.—The question of hibernating quarters, was further investigated since there is some uncertainty as to where the beetles pass the winter and such information might have a bearing on control. A careful search was made for hibernating beetles in many situations in and adjoining the orchards. These included rock piles, fence rows, wood-land, pasture, the sod mulch between trees and finally the sod directly under the trees. All situations except the last gave negative results. From cages placed under the trees and covering an area of approximately 480 sq. ft 257 beetles were captured, notwithstanding the fact that the infested June drops were collected the previous season in an effort to reduce the curculio population. In addition to beetles recovered from the cages in 1932 approximately 100 beetles were found by screening leaves and other debris under the trees.

CONTROL EXPERIMENTS.—In 1931 control tests were begun in the Ledgetop Orchard at Crown Point, N. Y During that season an attempt was made to control the curculio in an eight acre block of Tolman Sweet and Spy trees, by carefully collecting by hand the June drops before the new generation beetles had emerged from them. This procedure, while it undoubtedly greatly decreased the infestation, proved inadequate for commercial control This is evident when one considers both the number of beetles captured in the emergence cage records already cited, and the fact that there was severe injury in the experimental block during 1932. Studies were made to determine why the destruction of June drops as practiced the preceeding year had not given better control. As already pointed out the large number of beetles emerging from fruits that never reach the ground partially explains why destruction of the drops was not more successful. In addition, during 1931 the drops were collected only once. In 1932 it was demonstrated that the June drops should be picked up at least twice. If picking is delayed to get the entire drops at one time many beetles will have emerged from the fruits which fell first. In Table 1 a record is given of the beetles emerging from two pickings.

Since the late falling apples harbor so many beetles it seemed desirable to know how important, as a source of infestation, are apples thinned from the trees. For this purpose five bushels of 1½–2 inch apples thinned from one severely infested Wealthy tree were placed under a cheese cloth covered cage. From these five bushels 370 beetles emerged. Data in Table 2 shows that the initial emergence and the peak of emergence from these thinned apples are considerably later than in the case of June drops.

SPRAYING EXPERIMENTS.—During 1932 the major spray experiments were conducted in the Ledgetop Orchard at Crown Point, N. Y. A

TABLE 1. NEW GENERATION EMERGENCE RECORD. CROWN POINT, N. Y., 1932

Dates collected	*Cage No. 1 No. beetles	†Cage No. 2 No. beetles
July 20	0	—
July 21	2	—
July 22	2	—
July 23	22	—
July 24	28	—
July 25	68	1
July 26	110	1
July 27	169	2
July 28	158	5
July 29	93	2
Aug. 1	302	6
Aug. 2	392	5
Aug. 4	226	9
Aug. 8	229	21
Aug. 11	84	5
Aug. 15	226	14
Aug. 16	124	20
Aug. 22	68	12
Aug. 26	69	9
Aug. 30	23	2
Sept. 1	44	4
Sept. 6	8	0
Total	2,447	118

*In cage No. 1 were placed approximately 12 bushels of June drops which were collected before July 12th.

†In cage No. 2 were placed ½ bushel of June drops which fell after July 12th and were collected on July 19th.

TABLE 2. NEW GENERATION EMERGENCE RECORD FROM APPROXIMATELY FIVE BUSHELS OF APPLES THINNED FROM ONE WEALTHY TREE ON JULY 28TH, 1932

Dates collected	No. beetles
Aug. 1	1
Aug. 2	0
Aug. 4	1
Aug. 8	2
Aug. 11	1
Aug. 13	8
Aug. 16	13
Aug. 22	52
Aug. 26	139
Aug. 30	33
Sept. 1	75
Sept. 6	30
Sept. 21	15
Total	370

block of 225 Spy, Tolman Sweet, and occasional McIntosh trees was divided into seven plats. There was a heavy crop of Spy and Tolman Sweet in 1931 but a light crop in 1932.

The plats have been designated as I, II, III, IV, V, VI, and VII. The infestation at the beginning of the 1932 season was probably slightly less in plat I and increased in the direction of plat VII. The block of trees employed for spray tests during 1932 was the area where June drops had been collected in 1931 The spray applications were timed to check spring and early summer feeding of the overwintering beetles Table 3 summarizes the sprays each plat received and the results obtained. The data are based on examinations of the entire crop of representative trees in each plat

TABLE 3. APPLE CURCULIO SPRAYING EXPERIMENTS, CROWN POINT, N Y., 1932

Plat No	Dates sprayed	Materials used (water in each case to make 100 gallons)	Varieties checked	Total apples	Early injury No. apples	Early injury Per cent
I	May 18	Lead arsenate 5 lbs.	Tolman			
	May 29	Lime sulfur 2 gals.	Sweet	2,018	914	45.3
	June 2	Hydrated lime 5 lbs				
	June 13		Spy	2,846	507	17.8
Check tree in plat I		No treatment	Tolman Sweet	4,153	2,684	64.6
II	May 19		Tolman			
	May 29	Lead arsenate 3 lbs.	Sweet	1,419	1,184	83.43
	June 6	Lime sulfur 2½ gals.	Spy	1,997	846	42.4
	June 14					
III	May 17	Lead arsenate 5 lbs	Tolman			
	May 29	Lime sulfur 2 gals.	Sweet	2,823	1,218	43.14
	June 6	Hydrated lime 40 lbs.				
	June 14		Spy	2,684	599	22 31
IV	May 18	Lead arsenate 5 lbs.	Tolman			
	May 28*	Lime sulfur 2 gals.	Sweet	1,937	1,096	56.58
	June 6	Hydrated lime 5 lbs	Spy	1,728	489	28.30
	June 13					
V	May 17	Lead arsenate 6 lbs.	Tolman			
	May 28*	Lime sulfur 2 gals.	Sweet	1,657	990	60.04
	June 6	Hydrated lime 6 lbs.				
	June 14		Spy	2,371	435	18.34
Check tree in plat V	May 28	Lime sulfur 2½ gals.	Spy	3,661	2,447	66.83
VI	May 29	Lead arsenate 3 lbs.	Spy	6,239	2,742	43.94
	June 6	Lime sulfur 2½ gals.				
	June 13					
Check tree in plat VI		No treatment	Tolman Sweet	2,885	2,693	93.34
VII	May 17	Lead arsenate 6 lbs.	Tolman			
	May 28	Lime sulfur 2 gals.	Sweet	8,229	6,614	80.37
	June 3	Hydrated lime 6 lbs.				
	June 13		Spy	5,391	2,548	47.26

*On this date 1½ pints of fish oil were added to the spray formulae in plats IV and V.

Pink application—May 17, 18, 19. Calyx application—May 28, 29. Special applications—June 6, 13–14.

A number of materials have been tested against the apple curculio under laboratory and orchard conditions. These include lead arsenate, calcium arsenate, cryolite, Pysol 1-100, nicotine sulfate 1–100, nicotine tannate, and "white oil". Data are given only on arsenate of lead in various combinations since the others represent preliminary tests only. Of the newer materials Cryolite gave most promise.

SUMMARY.—Injury of the apple curculio in the Champlain Valley was about as severe in 1932 as in 1931. The destruction of June drops as carried out in a 1931 experiment did not appear to greatly lower the infestation for 1932. The drops should be picked up at least twice, but even where this is done many of the beetles will emerge from apples on the trees and thus lower the efficiency of this method of control. Results of spraying test with arsenicals in 1932 were not as encouraging as in 1931.

QUESTION: I should like to ask Mr. Hammer if he has noticed any difference in severity of infestation in orchards in the low lands as compared with orchards in the higher altitude.

MR. HAMMER: Practically all of the orchards where the infestation is in the Champlain Valley are rather low, to be sure, and they are bordered by wood lands.

Notes on New or Little Known Scale Insects. Last May specimens of a Lecanium on wistaria found at Greenwich, Conn. were submitted for identification and just recently have been identified by Dr. Harold Morrison of the U. S. Bureau of Entomology as *Lecanium excrescens* Ferris, a very interesting species not previously recorded from the eastern United States. This insect was sufficiently numerous to arouse some interest as to its nature and probable economic status.

Specimens of *Aspidiotus tsugae* Marlatt were found recently somewhat numerous upon Taxus at Field Point Park, Greenwich, Conn. and provisionally identified as this species by Dr. Morrison.

Umbrella pine has not been troubled heretofore to our knowledge by insects, and it was somewhat surprising to receive a shoot, accompanied by the statement that the insect was sufficiently abundant upon the tree to materially check its vigor. The material was submitted to Dr. Harold Morrison who considers it the species currently identified as *Lepidosaphes newsteadi* Sulc. An examination showed the scale insects numerous at the base of the needles and also upon the adjacent wood. They occurred in clusters of 3 to 8 or thereabouts and could be easily overlooked. All of the material mentioned in this note was collected by Mr. W. Bradford Mix of the Bartlett Tree Expert Company.

E. P. FELT, *Bartlett Tree Research Laboratories*

EXPERIMENTS ON THE CONTROL OF MITES INFESTING RASPBERRIES[1]

By RAY HUTSON, *Section of Entomology, Michigan State College, East Lansing, Michigan*

ABSTRACT

A description of damage, survey of distribution, and indication of loss sustained from mites, particularly *Tetranychus mcdanieli* McGregor, on raspberries in Michigan, together with control measures attempted and results attained. The distinguishing characteristics of *T. mcdanieli* are included and the observed habits of the mite detailed. Control studies with dormant and summer oils, glue, and contact poisons of plant origin alone and in combination are recounted. The effect of single applications and of series applications on different stages of *T. mcdanieli* are compared.

A series of three sprays of summer oil at one per cent strength reduced the mite population to an extremely low figure in May 1931, while an identical series of sprays applied just after the leaves came out in 1932 protected raspberries from damage by mites. Raspberry foliage is apparently entirely tolerant to sprays of one per cent summer oils.

During the last several years repeated reports of damage sometimes amounting to loss of crop on red raspberries by spinning mites have been coming in from Berrien County, located in the extreme southwestern part of Michigan. The injury consists in a browning and curling of the leaves, which in turn affects the fruit very much as a drouth does in that the fruit fails to develop properly. Fruit picked from infested canes, in addition to being lower in quality than normal fruit, is sometimes covered by mites to such an extent that, despite their inconspicuous coloration against such a background, the mites are apparent on the berries when marketed. The new growth is webbed together. In all infestations mites can be observed on both the upper and lower surfaces of the leaves. In addition to these effects, which, of course, occur in the early part of the season, the young shoots from which the next year's crop is to be secured do not make normal growth, for by the first of August, in severe attacks, no leaves are left on the shoots except tufts at the tips. Examination of leaves lightly infested with mites shows them to be covered with tiny areas from which the green coloring matter has been withdrawn. The desiccation taking place from these wounded areas is responsible for the brownness before noted. The monetary value of the damage inflicted by these mites has been variously estimated, but always runs into many thousands of dollars annually.

Investigations dealing with this pest of raspberries can best be treated under three headings: Systematic, habit, and control studies.

SYSTEMATIC STUDIES.—Appearance of the plants, together with the

[1]Journal Article No. 141 (n. s.) from the Mich. Agr. Exp. Sta.

superficial resemblance of all other mites subsequently found to be present, at first gave the impression that *Tetranychus bimaculatus* Harvey was responsible. Failure of control measures and subsequent microscopic examination of living specimens disclosed the presence of a mite complex on the infested raspberries in which *bimaculatus* was numerically inferior to other species. Collection, preparation, and submission of specimens suitable for microscopic study to E. A. McGregor resulted in the determination that two of the species of mites present, in addition to *bimaculatus*, were *Paratetranychus ilicis* McGregor, previously reported from South Carolina on holly (*Ilex opaca*), and a new species, which has been described (2)[2] recently as *Tetranychus mcdanieli*, McGregor (Type slide, Cat. No. 1029, U. S. N. M.); this last-named species can be distinguished by microscopic examination from *T. bimaculatus* by the following characters: (2)

"*T. bimaculatus*. Female: Color usually brick or ferruginous red; mandibular plate with slight median anterior notch; femur noticeably exceeding tarsus. Male: Penis with strongly developed basilar lobe, shaft bent upward at about 90°, ending in a very blunt barb.

"*T. mcdanieli*. Female: Color usually deep amber; mandibular plate with no anterior emargination; femur equalling tarsus. Male: Penis with almost no basilar lobe, shaft bent upward and forward about 330° from axis of shaft, then bent sharply backward as a sickle-shaped acuminate point, the distal portion thus forming an S-shaped hook."

Indebtedness to E. A. McGregor for his kindness in identifying the three species of mites concerned is gratefully acknowledged.

Habit Studies.—*T. mcdanieli* is the mite which occurs in the greatest numbers associated with the type of injury described in all cases studied, although it is seldom found on raspberries showing the described lesions without one or both of the other two species. The constancy of its presence on injured plants and its numbers, together with the appearance of plants having almost pure cultures of *T. mcdanieli*, leaves little doubt that this species is responsible for the abnormal condition of the plants.

Microscopic examination of raspberry canes during January and February, 1931, revealed *T. mcdanieli* present beneath the scales about buds and also under loose strips of bark upon the canes. So far as has been determined, this species does not winter in trash or rubbish on the ground among the canes. *T. mcdanieli* is present on raspberry foliage as soon as the buds open enough to show green. Raspberry plantings on soils with good water-holding capacity do not suffer as severely or as often as plantings upon dry soils. All three species of mites discussed in

[2]Reference to authorities cited is indicated by figures in parenthesis.

this paper occur on sow thistle (*Sonchus arvensis*) in infested plantings of raspberry *T. mcdanieli* becomes extremely abundant on spent canes after harvest and migrates to young canes as the old canes become unsuitable as feeding places.

CONTROL STUDIES.—Following the first reports of damage to raspberries by mites, a number of materials and combination of materials were tried as single applications against the pests. Nicotine with soap, Derrisol and Derrisol with soap were the principal things tried, for the whole problem was complicated by the danger of injury to the foliage. This danger is particularly imminent in the case of sprays containing sulphur. In the infested region the danger of burning raspberry plants with sulphur-bearing sprays is so well-known that growers are with considerable difficulty persuaded to spray this plant at all. As a consequence of the failure of preliminary efforts at control, of the danger of injury, of the revelations of the systematic findings, and of the habits of *T. mcdanieli*, the responsible organism, an entirely new approach to the problem was undertaken in the spring of 1931.

As originally planned, the experimental work was to consist of a series of sprays beginning late in the dormant period and continuing through the early part of the season, utilizing sprays that had been demonstrated as innocuous to the plant at the particular time they were applied The reason for a modification of the objective will appear in Table I and its ensuing discussion. Following the results of the first series of tests, the problem resolved itself into a quest for a bland, readily obtainable, easily applied, cheap material compatible with the fungicide commonly used on red raspberries which when applied as a series of sprays timed to avoid observed resistant stages, would reduce the mite population to a low figure.

Plots for the study of spray treatments against mites were laid, early in the spring of 1931, in plantings which had in 1930 suffered severely from mite damage. *T. mcdanieli* was present on the buds at the time plots were laid out. Plots consisted of two rows about fifteen rods long for each treatment with an unsprayed row between each plot for a check. Site and arrangement of the planting afforded a gradation in every plot from well-drained to very dry soil, a consideration of importance, since mite injury is more serious on dry soils, as shown by the habit studies.

All sprays were applied with an orchard sprayer, developing 250 pounds pressure. Driving between the rows of plants a one-side application was made to both sides of every row. The spray was forced in among the foliage by moving a regular orchard spray gun adjusted to a fine spray up and down constantly at an estimated distance of three or

four feet from the particular plants being sprayed. This procedure, as determined by inspection, insured thorough coverage for all parts of all plants in each row. This method of spraying required about one gallon of spray per rod of row and was eminently satisfactory in preventing injury to the easily-broken new growth.

Evaluation of the various treatments was accomplished by collecting from each plot 100 shoots at random and then counting the number of live mites upon a leaf from the same relative position upon each, and comparing the results of such counts with the infestation of the check. The infestation of the check was determined by averaging data secured from all check rows by the same procedure as that employed on the treated plots. For reasons of convenience in handling, the counts were made upon the third leaf from the base of the shoots.

The results of single applications of various materials, together with other relevant data, comprise Table 1.

TABLE 1. RESULTS (TAKEN MAY 4, 1931) OF SINGLE APPLICATIONS FOR *Tetranychus mcdanieli*

Spray treatment and dilution	Date applied 1932	No. live mites per 100 leaves
Diamond paraffin Kayso emulsion (66⅔% oil) 1–50	April 14	768
Proprietary oil A—1–50	14	644
Proprietary oil B—1–50	14	790
Glue, 15 pounds in 100 gallons	April 23	114
Nicotine sulphate 1 pint, plus Penetrol ½ gallon in 100 gallons	23	473
Pyrethrum (.9% pyrethrins) 1 pint, plus Penetrol ½ gallon in 100 gallons	23	253
Derrisol 1 pint, plus 2 pounds Ivory soap in 100 gallons	23	247
Volck (medium)	23	165
Verdol	23	201
Check—No spray	23	822

May 14 all these plots were heavily re-infested. These plots set but did not mature a crop of berries because of mite injury.

Observations made during the process of making the counts detailed above showed numbers of hatching mite eggs present on the leaves. In addition, but few adult mites could be found. Further observation showed almost all of the eggs hatching shortly and seemed to denote that the mites were surviving the treatments in the egg stage. Whether this survival is dependent upon resistance of the eggs or results from insufficient spray coverage has not as yet been completely determined, although the former hypothesis is indicated by the observed care in spraying and the experience of other workers (1, 2) with the related *Tetranychus bimaculatus*.

Following determination that single treatments could not be depended upon to eliminate enough mites to prevent heavy re-infestation, a num-

ber of plots were laid out on the same plan to ascertain the effect upon the mite population of series of application timed to forestall the possibility of egg-laying between sprays.

Although all of the materials applied as single applications on May 4, 1931, give marked reductions in the number of mites, considerations of plant tolerance, availability, ease of application, cost, and compatibility with bordeaux, in addition to their performance as evidenced in Table 1, restricted the materials used in series applications to summer oils at 1 per cent strength. A resume of tests with series application of summer oils is afforded by Table 2.

TABLE 2. RESULTS OF SERIES APPLICATIONS OF ONE PER CENT SUMMER OILS FOR *T. mcdanieli*. (LIVE MITES PER 100 LEAVES)

Material	Applications	No. live mites per 100 leaves	Observations
Volck (medium)	2	127	Eggs becoming scarce. At picking time these
Verdol	2	145	plots began to show re-infestation.
Check	0	2884	Leaves webbed together, innumerable eggs.
Volck (medium)	3	28	These mites on leaves apparently not hit by
Verdol	3	32	spray. No noticeable re-infestation during season. Eggs apparently absent.

Inspection of the figures in Table 2 shows little difference in efficiency of the materials tested in series applications. The difference in results between two applications and three applications is not particularly impressive until the subsequent history of the plots is examined under remarks. The re-infestation on the plots receiving two applications is noted at the time raspberries are picked, while the plots receiving three applications were free from injurious numbers of mites throughout the remainder of the season. These data seem to indicate that control of spinning mites on raspberry can be accomplished by three applications of one per cent summer oils and the evidence apparently denotes that this is brought about by destroying the mites in their nymphal stages before they have deposited eggs. It is further indicated that the spinning mite, *T. mcdanieli*, reproduces at a rate comparable with that of *T. bimaculatus* (1, 2). This can be seen from again referring to the tabulated data. The re-infestation noted strikingly supports this contention. Reproduction, then, is so rapid under the conditions in Berrien County, Michigan, that almost complete kill is necessary for control. That this is dependent in large measure upon thoroughness of application can be understood from the observations in Table 2, where the mites found on leaves sprayed three times seemed to have been missed by the spray.

During April and May, 1932, the experimental findings of Table 2 were tested by applying a series of three sprays of one per cent summer oil to a planting infested with *T. mcdanieli*. The results confirmed the previous findings. Additional confirmation was furnished during 1932 by observations on the results obtained by practical application of this series of sprays by growers.

No spray injury to raspberry foliage was observed during the course of these experiments.

ACKNOWLEDGMENT.—Acknowledgment is gratefully made to Dr. R. H. Pettit for counsel in the course of these experiments, to Prof. E. I McDaniel for aid in the identification of the mites concerned, to M. G. Farleman for assistance in making applications and counts, and finally to the County Agent and growers of Berrien County, whose cooperation made the tests possible.

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MR. BLAUVELT: I should like to ask Mr. Hutson at what time these sprays were applied in relation to time of picking of the fruit.

MR. HUTSON: The most efficient sprays were put on just after the plants began to show green. That, of course, appears in the paper, but we also found that with the 1 per cent oil, if you wanted to, you could put them on while picking, and pick the next day.

We also found that as many as sixteen sprays of 1 per cent oil can be applied to a raspberry plant at five-day intervals and still have no injury. Higher concentrations burned.

MR. BLAUVELT: Did the 1 per cent oil give a high kill of eggs?

MR. HUTSON: No. That is the whole trouble. You don't get the eggs.

THE HOST RELATIONS OF OUR CHERRY FRUIT FLIES

By HUGH GLASGOW, *New York Agricultural Experiment Station, Geneva, New York*

ABSTRACT

In the eastern states the cherry fruit flies, *Rhagoletis fausta* and *Rhagoletis cingulata*, have been found to breed freely in certain native wild cherries, particularly in the common black cherry *P. serotina* and the native bird or fire cherry *P. pennsylvanica*

In this region *P. serotina* appears to be the principal native host for *R. cingulata*, while *R. fausta* is confined chiefly to *P. pennsylvanica*. These two fruit flies are not well adapted to the native choke cherry, *P. virginiana*, and this fruit appears to be of little importance as a host for either species

In common with many other insect pests, our cherry fruit flies, *Rhagoletis fausta* and *Rhagoletis cingulata*, are native species that are of little or no economic importance except as they have adapted themselves to an introduced host,- in this case the common cultivated cherries, *Prunus avium* and *Prunus cerasus*.

Studies having to do with the cherry fruit flies in the past have been directed mainly toward solving those problems growing out of the direct relation of these insects to their introduced hosts.

The interrelations of the pests with their wild or native host plants and the possible bearing such relations may have on the prevalence and distribution of the insects in cultivated areas have not received the consideration they seem to merit.

The methods now in general use for the control of the cherry fruit flies are surprisingly effective as judged by the standards commonly accepted for other fruit pests. Notwithstanding this, however, there are commercial cherry plantings where the control persistently falls well below the standards that most commercial cherry growers have come to accept as a matter of course. Many such cases have been rather difficult to account for and cannot always be satisfactorily explained on the grounds of inefficient spraying, but point rather to possible contamination from some outside source.

During the past four or five years we have given considerable attention to this aspect of the general cherry fruit fly problem and in the course of these studies have examined a number of different fruits, both native and introduced, that might possibly serve as a reservoir for the cherry fruit flies and a source of contamination for commercial cherry plantings. The fruits so far examined do not by any means exhaust the list of possible host plants or cover the entire range of the insects, but do include many of the commoner fruits that seemed likely to harbor the insects or to be associated with cherry plantings in New York.

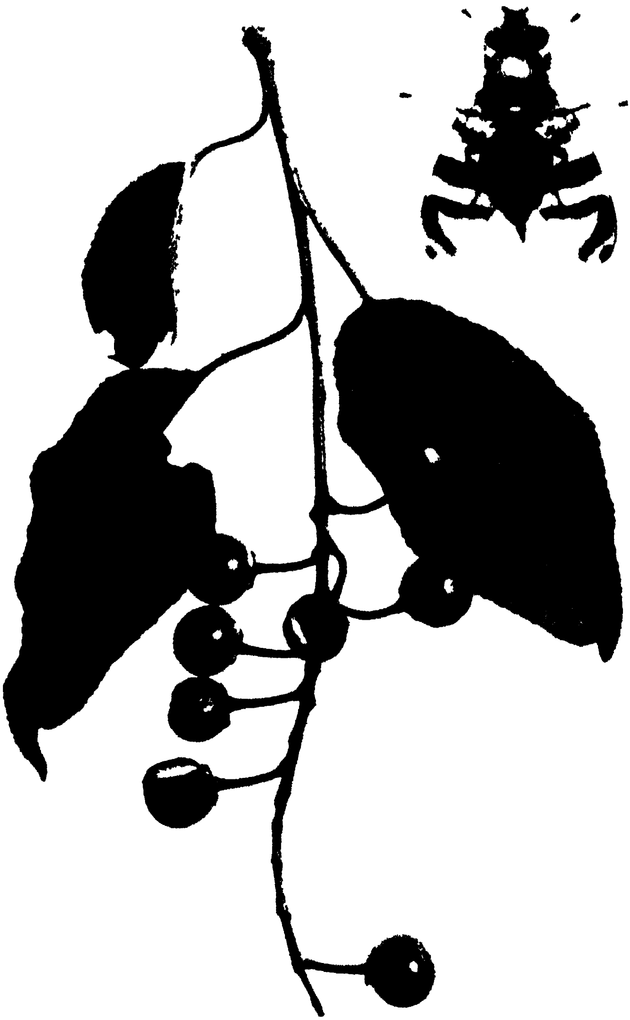
The general routine followed in checking the various fruits for possible fruit-fly infestation was comparatively simple and consisted in general of a preliminary examination to establish the presence or absence of larvae which, if found, were concentrated in large out-door emergence cages, from which the adults were collected for identification as they emerged the following spring.

Wherever possible the fruits to be examined were selected from in or near badly infested cherry orchards known to harbor one or both species of the fruit fly, or in the neighborhood of some of the heavily infested native hosts of these insects. The preliminary inspections were made first by direct examination for the presence of egg punctures or maggots, supplemented later, on a more extensive scale, by the collection of quantities of the fully ripe fruits which were held under observation for the appearance of maggots or puparia or immersed in cold water for several minutes to hasten the escape of the maggots from the fruit. Under this treatment the more mature maggots were found to very largely leave the fruit and collect in the bottom of the container. The fruit was later macerated in some cases and a detailed search made for the presence of fruit fly larvae, but this procedure was not generally followed

Whenever fruit fly larvae were found a cage was stocked with a quantity of the fully ripe fruit to provide for emergence records the following spring. In stocking these cages the fruit was either placed directly on the ground in a thin layer or more commonly was supported on a coarse mesh wire screen approximately the size of the cage and raised a few inches above the ground. Such a support proved a much more effective method for concentrating the maggots than by placing the fruit directly on the ground since it makes possible the use of a much greater volume of fruit and allows for its renewal at frequent intervals as the maggots escape or the fruit commences to break down. The insects on escaping above such a support are able to make their way thru the meshes of the screen to the ground where conditions are more suitable for hibernation than directly beneath a mass of decomposing fruit.

The type of emergence cage adopted for this work covered a plot of ground of approximately forty square feet, being eight feet long, five feet wide, and three feet high. These dimensions provide for a cage covering a relatively large surface but still reasonably stable,—high enough to permit a man moving about inside, but sufficiently compact to allow for convenient transportation and storage when dismantled.

In construction the cage consists merely of a simple skeleton framework of boards approximately three inches wide. For covering, a sheet



Fruit of the native black cherry, *Prunus serotina*, together with the fruit fly, *Rhagoletis cingulata*, commonly found associated with it. (Two of the eight fruits in this cluster were infested, two having been opened to show the insects within.)

Plate 21

Fruit of the native bird or fire cherry *Prunus pennsylvanica* with an associated fruit fly, *Rhagoletis fausta* (Two of the infested fruits have been opened and the maggots exposed)

of coarse mesh cheesecloth of from 20 to 30 threads to the inch and twelve feet wide may be used. A cage of this type may yield several hundred adults if properly stocked and the fruit moderately infested. The number of flies recovered in the case of some of the smaller fruits and with a higher rate of infestation may be much greater. Of the thirty-nine fruits recorded in Table 1, adult fruit flies were actually recovered from only fifteen, and the cherry fruit flies from but six. Eggs, and in some cases maggots, were found in thirty of the thirty-nine fruits examined, indicating that these insects are somewhat lacking in discrimination in their egg-laying habits and undoubtedly oviposit in many fruits in which there is no possibility of the species surviving.

The apple fruit fly, *Rhagoletis pomonella*, for example, has been repeatedly observed ovipositing in the fruit of the cherry, while one or both species of the cherry fruit fly have been seen to oviposit in fruit of Lonicera, Cornus and Symphoricarpos. In captivity the dogwood fruit fly (*R. tabellaria*) has been found to oviposit sparingly in the cherry, altho in none of these instances have the species in question been able to develop.

Of the various fruits so far examined for the possible presence of either of the cherry fruit flies, the introduced *Prunus mahaleb* and the native *Prunus serotina* and *Prunus pennsylvanica* are the only host plants aside from the cultivated cherries from which the adults have actually been reared in any numbers.

Egg punctures and young larvae, presumably of one or both species of cherry fruit flies have been found very commonly in the fruit of the native choke-cherry (*Prunus virginiana*), but it appears that these very rarely complete their development in this host. That the eggs and larvae observed in the fruit of the choke-cherry are really those of the cherry fruit flies is borne out by the fact that they are particularly apt to be encountered in choke-cherries growing in or near neglected cherry plantings where the fruit flies are known to be prevalent, and that females of both *R. cingulata* and *R. fausta* have been observed ovipositing in this fruit in the field. From the readiness with which fruit fly eggs are deposited in the choke-cherry and the fact that they may hatch and the resulting maggots develop for some time, it seems strange that there should not be a closer affinity between these insects and this exceedingly common native cherry.

Repeated attempts to rear the cherry fruit flies from the choke-cherry have generally resulted in failure, only one male and two females of *R. fausta* having been recovered from this fruit. No adults of *R. cingulata* have so far been reared, altho in the preliminary examinations of

the fruit a total of two typical puparia of this species was obtained, and these findings suggest the possibility that in rare cases the choke-cherry may serve as a host for this species. Whether this ever actually occurs appears to be of little practical significance since the choke-cherry can certainly not be regarded as a preferred host for either *fausta* or *cingulata* and, in New York at least, need cause no concern as introducing a possible complicating factor into the general problem of cherry fruit fly control. This is indeed fortunate for *P. virginiana* is by far the commonest wild cherry thruout the cherry growing sections of the State, occurring as it does in nearly every neglected fence row, and the problem of cherry fruit fly control would be correspondingly involved if this fruit served as one of the preferred hosts of the insects.

As contrasted with the choke-cherry the fruits of the two common native wild cherries (*P serotina* and *P. pennsylvanica*) are practically always found to harbor maggots of the cherry fruit flies, the infestation often being severe While the degree of infestation for these wild hosts naturally varies in different localities and with the season, it is rare indeed to see either of these cherries in fruit without also finding the fruit flies associated with them. Both of these native wild cherries are widely distributed and occur not only in agricultural sections but also in some of the most inaccessible parts of the state, far from any plantings of cultivated cherries. No matter where found, however, even in the most remote parts of the Adirondack Mountain region, one may confidently expect to find them infested by the cherry fruit flies.

That the fruit flies are well adjusted to these wild hosts is indicated by the readiness with which the fruit is attacked and the heavy infestations of maggots that may be observed, as well as by the relatively high percentage that transform to adults. That these insects are perhaps more completely adjusted to their native hosts than to the cultivated cherries is suggested by the readiness with which the flies oviposit in their fruits. In the case of the cultivated cherries it often happens that only a relatively small percentage of the oviposition punctures are found to actually contain eggs, while in the wild fruits the ratio is reversed and eggs are commonly found to have been placed in most of the punctures made by the females.

In cultivated cherries the fruit fly larvae are generally surrounded by an abundant supply of food, as a rule greatly in excess of the actual needs of the insect. In comparison with cultivated varieties the fruit of *P. pennsylvanica* is very small and one might be inclined to doubt the ability of an insect the size of *R. fausta* to complete its development in a cherry of this size. That the species is not seriously handicapped by the size of

the individual fruits is indicated by the readiness with which it breeds in this variety and the size of many of the resulting individuals. While it is true that very many of the flies reared from bird cherries are small and appear to have developed in a single fruit, many on the other hand are fully as large as any that have been reared from the cultivated cherry. This is not difficult to account for since the larvae are not necessarily confined to the original fruit in which the egg was deposited, but have been found to migrate freely from infested to clean fruit in the same cluster, particularly when the fruits are in direct contact. The tendency to shift from infested to clean fruit does not appear to be so common in the case of *R. cingulata* breeding in the black cherry, possibly because the larger size of the fruit affords the larva a more liberal supply of food.

While both *P. pennsylvanica* and *P. serotina* have been found to serve as important food plants for the cherry fruit flies, the host preferences displayed by these insects is rather surprising. Where either species of fruit fly will attack the two introduced, cultivated cherries (*P. avium* and *P. cerasus*) with equal readiness, their relations to the native wild cherries appear to be much more sharply defined. *R. fausta* seems to be confined strictly to the bird cherry (*P. pennsylvanica*), never having appeared in any of our rearings from the native rum cherry, while *cingulata* on the other hand seems to be just as closely restricted to *P. serotina* and has never so far been recovered from the fruit of *P. pennsylvanica*, altho the rearing records in both cases are based on a large volume of fruit taken from widely separated localities.

The common names applied to the cherry fruit flies that are now in general use are fairly descriptive and therefore serve a useful purpose. As supplementing these accepted common names, however, that of bird or fire cherry fruit fly as applying to *R. fausta* and rum cherry fruit fly in the case of cingulata might well be suggested on account of the clear-cut host relationship that exists between these insects and their native food plants and the obvious bearing this may have on the prevalence of either species in a given locality as well as on the measures that may have to be adopted in the carrying out of any control program.

It may be of interest to note here that of the two cherry fruit flies, *R. fausta*, the species that regularly appears first in cultivated cherry orchards, is the one that in nature is associated with the early maturing *P. pennsylvanica; R. cingulata*, on the other hand, being confined to the later ripening *P. serotina*.

As is indicated in Table 1 adults of the cherry fruit flies were recovered from but a relatively small proportion of the fruits in this series. Fruit fly eggs, however, and sometimes maggots as well, were often encount-

ered in a considerable proportion of the fruits from which neither mature larvae or adults were recorded. Of this series of nearly forty fruits it will be noted that Rhagoletis adults were recovered from but fourteen, while only five closely related fruits yielded adults of the cherry fruit flies. Rhagoletis eggs, however, were observed in a large part of the series, thirty in all, and it is evident that our common fruit flies will oviposit in a much more extensive group of fruits than might be indicated by rearing records alone.

RECORD OF EXAMINATION OF POSSIBLE HOST PLANTS FOR PRESENCE OF CHERRY FRUIT FLIES (*R. fausta* AND *R. cingulata*)

Host plant	Rhagoletis fausta	Rhagoletis cingulata	Eggs or larvae of Rhagoletis	Other species of Rhagoletis reared
Prunus avium	+	+	+	—
Prunus cerasus	+	+	+	—
Prunus mahaleb	+	+	+	—
Prunus tomentosa	—	—	+	—
Prunus virginiana	+	+?	+	—
Prunus serotina	—	+	+	—
Prunus pennsylvanica	+	—	+	—
Prunus triflora	—	—	+	—
Prunus domestica	—	—	+	—
Prunus americana	—	—	+	—
Prunus hortulana	—	—	—	—
Cornus canadensis	—	—	+	+
Cornus stolonifera	—	—	+	+
Cornus paniculata	—	—	+	+
Viburnum opulus	—	—	—	—
Viburnum lentago	—	—	—	—
Viburnum alnifolium	—	—	—	—
Rhamnus cathartica	—	—	—	—
Rhamnus alnifolia	—	—	—	—
Sambucus canadensis	—	—	—	—
Vitis labrusca	—	—	+	—
Psedera quinquefolia	—	—	+	—
Lonicera sempervirens	—	—	+	—
Lonicera canadensis	—	—	+	—
Ribes rotundifolium	—	—	+	—
Ribes grossularia	—	—	+	—
Ribes floridum	—	—	+	—
Ribes vulgare	—	—	+	—
Malus malus	—	—	+	+
Malus baccata	—	—	+	+
Crataegus melanocarpa	—	—	+	+
Juglans nigra	—	—	+	+
Symphoricarpos racemosus	—	—	+	—
Vaccinium pennsylvanicum	—	—	+	+
Vaccinium corymbosum	—	—	+	+
Vaccinium macrocarpon	—	—	+	—
Berberis vulgaris	—	—	+	—
Elaeagnus multiflora	—	—	—	—
Shepherdia argentea	—	—	—	—

By no means all the oviposition records indicated in Table 1 represent eggs deposited by the cherry fruit flies, but certainly these species will

deposit eggs readily in fruits where there is little or no chance of the insects completing their development.

In addition to the Prunus recorded in Table 1 which serve as well defined hosts for the cherry fruit flies, these insects have been observed ovipositing in the fruit of Cornus, Lonicera, Japanese and American plums, *Ribes vulgaris*, and Symphoricarpos.

It might be of interest here to go into somewhat more detail than indicated in the table in considering the breeding records from Cornus. It was at first thought highly probable that *Cornus stolonifera* might prove an important host for *Rhagoletis fausta* since a large group of this Cornus which was under observation happened to be located in a badly infested cherry orchard and showed a typical fruit fly infestation of from 30 to 40 per cent. Later rearing records, however, revealed only adults of *Rhagoletis tabellaria*[1] and indicated strongly that this fruit does not in any case serve as a host for the cherry fruit flies, for there was ample opportunity in this orchard as well as in other similar cases for the fruit to have become infested if this were possible. *Rhagoletis tabellaria* is of special interest here because the species was first recorded by Fitch[2] who, in his original description of the species records it as having been taken from a cherry orchard, and the species has been mentioned occasionally in subsequent reports as possibly infesting the cherry. Our rearing records do not bear this out, for extensive rearing tests have been carried on with cherries growing near heavily infested groups of Cornus and *tabellaria* has never been recovered in a single instance.

It is apparent that *R. tabellaria* is strictly a dogwood fruit fly, while on the other hand it is equally apparent that the cherry fruit flies do not breed in the fruit of Cornus; at least not to any appreciable extent.

While these studies are not complete enough as yet to insure the finality of some of the negative findings recorded, and while there may well be other important host plants among the many wild Prunus occurring in other parts of the range of these insects that we have had no opportunity to study, it would appear from the results so far secured that in New York at any rate and from a practical standpoint, *P. serotina* and *P. pennysylvanica* are the only wild, native hosts of the cherry fruit flies that need be given serious consideration.

MR. HUTSON: I might say Mr. Glasgow's findings in the case of the cherry fruit flies infesting wild hosts are in substantial agreement with the findings we have for the wild hosts of the cherry fruit fly in Northern Michigan.

[1]Identified through the kindness of Dr. J. M. Aldrich.
[2]Fitch. Rept. Nox. & Benef. Ins. N. Y., I, p. 66, 1856.

Another point that occurs to me at this time is that I have heard no one mention the wild host plants of *Rhagoletis pomonella*. I have collected a gallon of hawthorn berries from an isolated tree on a golf course near Lansing, taken them in, and secured over 200 specimens from that gallon. We have records from all over the state similar to that. The so-called English hawthorn, an ornamental, and Paul's scarlet thorn also served as hosts.

A FIELD AND LABORATORY TECHNIQUE FOR TOXICOLOGICAL STUDIES OF THE CODLING MOTH[1]

By E. H. Siegler and Francis Munger, *United States Bureau of Entomology*

Abstract

The "apple plug" method, as described in this paper, was developed for the purpose of minimizing certain difficulties experienced in insecticide tests against the codling moth. In using the "apple plug" method, small plugs of apple, uniformly sprayed with the insecticide under test, are sealed in glass cylinders. One codling moth egg is confined with each plug and, upon hatching, the larva encounters the insecticide as it attempts to gnaw its way through the skin of the fruit.

In September, 1929, the senior author issued a mimeographed paper describing the "apple plug" method as a result of developing a technique which seemed worthy of trial in connection with insecticide studies against the codling moth.[2]

It is the purpose of the present paper to discuss the work further and to present data since obtained using the technique herein described.[3]

In an endeavor to reduce the losses occasioned by the codling moth, many tests of insecticides have been made, both in the field and in the laboratory. In the field the usual practice has been to lay out plats in apple orchards and to spray them in accord with a predetermined program. The drop fruit has been examined throughout the season and the harvested fruit inspected as soon as picked.

[1]The writers are indebted to J. B. Gahan and Miss E. J. Lamond for assistance in carrying out these studies.

[2]During the season of 1931, Lathrop and Sazama conducted a laboratory-field test, closely following the plan proposed in the original paper by the senior author. These workers, however, used entire apples as sample fruit and placed on each apple 10 newly hatched larvae of the codling moth. They used "a ring of sticky banding material about the calyx of each apple to prevent the larvae from escaping via the supporting wire."—F. H. Lathrop and R. F. Sazama, A laboratory-field method for the study of the efficiency of codling moth sprays. Journ. Econ. Ent., Feb., 1932.

[3]We have also used this method in connection with the oriental fruit moth on peach, quince, and apple.

As a result of certain conditions in the field some of our data were unavoidably disappointing and at times misleading. Although the work was well planned and executed, the data frequently failed to indicate with scientific accuracy some of the primary objects of the experimentation, namely, the comparative value of the insecticides and the merits of different spray schedules

The heterogeneity of plats, as influenced by initial differences in the insect population, and subsequent variations because of moth migration; proximity to abnormal sources of infestation; natural enemies; and crop yield variants have largely been responsible for most of the discordant data.

Certain of the objectionable features of the field methods quite generally used, including some which have contributed to field heterogeneity, may be specified as follows

(1) The necessity of repeating the same tests annually over a considerable period

(2) The necessity of using large plats

(3) The loss of a season's work when insect infestation was very light

(4) Examination and inclusion of drop fruit, with its somewhat questionable contributory value

(5) The rush of taking harvest results and consequent chances for inaccuracies.

(6) Variance because of blemished fruit, as scab cracked, frost pitted, and curculio and hail marked.

(7) Lack of timely data as to when fruit is inadequately protected by spray material.

(8) Lack of data on the effect of removal of spray material by unusually heavy rains.

In the insecticide tests in the laboratory most of the studies have been confined to the spraying of picked apples, on each of which were placed a number of newly hatched codling moth larvae. With this procedure we have experienced the following difficulties:

(1) In making a uniform spray coverage over the entire surface of the apple.

(2) In obtaining a high or uniform infestation on the unsprayed fruit used as checks.

(3) In determining the percentage of cannibalism among larvae.

(4) In locating the numerous larval entrances.

(5) In finding unblemished fruit for the tests.

(6) Mortalities resulting from the use of a sticky material either to restrict the movements of the larvae or to prevent their escape from the suspended fruit.

The plan of using the field-laboratory method herein proposed for nonvolatile sprays is briefly as follows:

(1) Lay out the plats in the usual way, except on a smaller scale.

(2) Spray in the usual way and in accord with the customary schedules.

(3) Provide an ample supply of codling moth material for rearing purposes.

(4) At stated intervals throughout the season visit experimental plats and remove sample apples from lower, middle, and upper sections of the count trees. Plug the fruit while in the field and bring it to the laboratory in special carrying vials to avoid rubbing of the sprayed surface.

(5) Test side, calyx, and stem plugs from each plat.

(6) At the laboratory seal each apple plug in a vial provided for the purpose (7 /8 inch inside diameter by 2 inches in length).

(7) After the apple plug has been properly sealed in the vial, place in each vial a codling moth egg in the black-spot stage.

(8) Examine the larvae for results in about 4 or 5 days from the time of hatching.

Preparation of apple plugs in toxicological test against the codling moth: *A*, Removing apple core with cork borer; *B*, removing apple plugs with short cork borer; *C*, glass cylinders, ⅞ inch by 2 inches, for holding apple plugs; *D*, apple plugs in carrier ready for spraying; *E*, automatic spraying apparatus used for spraying apple plugs for laboratory tests against the codling moth. See plate 22.

Sealing sprayed apple plugs in toxicological study of the codling moth: *F*, using test tube to push down apple plug in cylinder; *G*, sealing plug with paraffin; *H*, sealing plug with lead resinate; *I*, covering raw end of plug with paraffin. See plate 22.

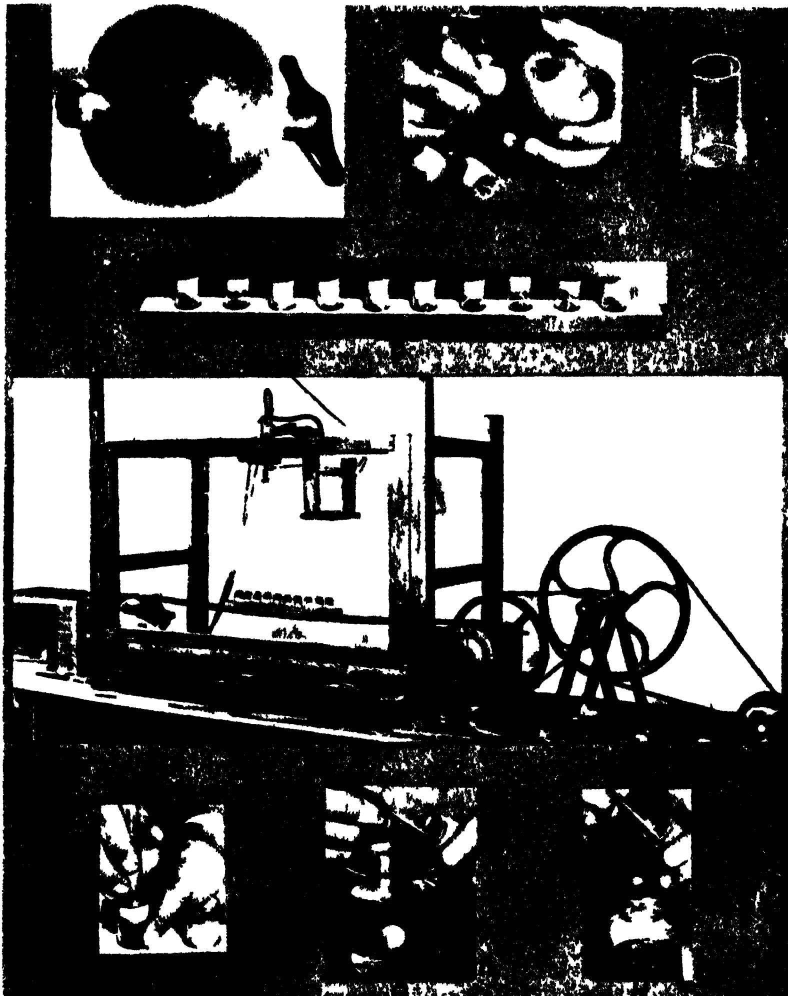
The materials required for making tests, field studies, and laboratory studies are as follows:

(1) *Codling moth eggs*, in the black-spot stage.

(2) *Apples:* It has been found that the Stayman Winesap is suitable for purely laboratory tests because of the ease with which larvae pierce the skin.

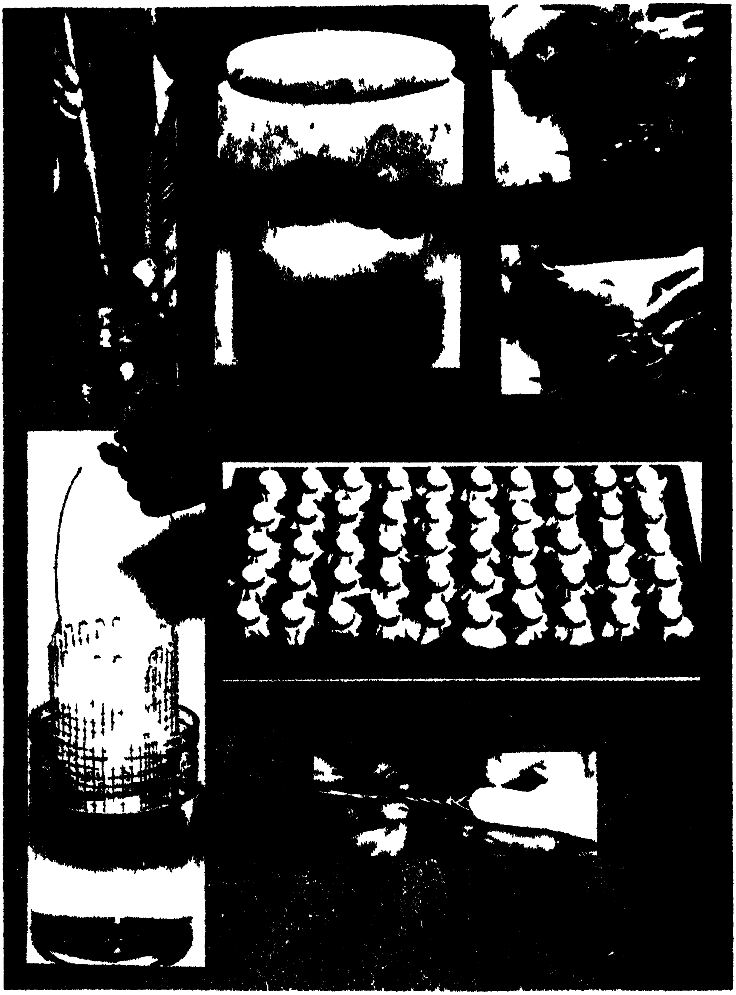
(3) *Cork borer*, used to remove the apple core (Pl. 22, *A*) and a short cork borer (Pl. 22, *B*) for cutting out apple plugs that will fit snugly into glass vials.

(4) *Glass cylinder*, 2 inches in height (Pl. 22, *C*) made from tubing 7 /8 inches inside diameter.



A Removing apple core with cork borer B Removing apple plugs C Glass cylinders 7/8 inch by 2 inches for holding apple plugs D Apple plugs in carrier ready for spraying E Automatic spraying apparatus used for spraying apple plugs for laboratory tests against the codling moth F Pushing down apple plug in cylinder G Sealing plug with paraffin H Sealing plug with lead resinate

Plate 23



I.—Covering raw end of plug with paraffin. J. Incubation of codling moth eggs in a battery jar. K. Cutting out eggs deposited on wax paper. L. Transfer of egg to vial containing apple plug. M. Holding rack for completed vials. N. Cleaning vial. O. Wiping vial.

(5) *Test tube* (Pl. 22, *F*) used to push the plugs into the vials. The sprayed surface is unmarred, as the rim of the plug touched by the test tube is covered subsequently with paraffin and lead resinate in the sealing process.

(6) *A spray gun* of the paint-sprayer type (Pl. 22, *E*), operated by compressed air under constant pressure, is used for spraying the plugs for laboratory tests.

(7) *A revolving endless* belt (Pl. 22, *E*) for laboratory tests, driven by a motor, is used to carry the plugs (10 at a time) through the spray. Thus a uniform covering is obtained on each plug.

(8) *Sealing materials:* Paraffin, lead resinate, absolute alcohol, used for sealing the plug in the vial.

(9) *Electric hot plate*, (Pl. 22, *G*) for melting paraffin.

(10) *Electric fan*, for drying the sprayed plugs.

(11) Small camel's hair brushes, for painting the paraffin and lead resinate on the plug in sealing it to the vial (Pl. 22, *G* & *H*).

(12) *Miscellaneous:* (*A*) Circular piece of fine mesh sheeting, 2 inches in diameter; (*B*), scalpel for examining fruit for larval entrances; (*C*), hand lens to aid in examining plugs.

Plugs to be used for laboratory insecticide tests should be prepared in the following manner:

(1) Unsprayed apples are preferable but if these are not available thoroughly wash the apples in 1 per cent solution of hydrochloric acid to remove the arsenical residue.

(2) Remove cores (Pl. 22, *A*).

(3) Cut plugs from unblemished surfaces of the apples. (Pl. 22, *B*).

(4) Insert plugs in the vials so that the cut edge of the apple skin is flush with the top edge of the vial. (Pl. 22, *D*).

(5) Spray the apples with the material to be tested. (Pl. 22, *E*).

(6) Dry the plugs by means of a fan.

(7) Push the plugs down about ½ inch in the vial by means of the open end of a close-fitting test tube so as to prevent rubbing the sprayed surface. (Pl. 22, *F*).

(8) Seal the edge of the apple skin to the vial with a brush dipped in hot paraffin. (Pl. 22, *G*).

(9) Paint the paraffin with two coatings of a solution of lead resinate in alcohol using 25 grams of lead resinate in 100 cc of solution (Pl. 22, *H*), allowing 5 minutes between coatings. This adds a hard glazed covering to the paraffin which prevents the larvae from boring through the paraffin seal. Allow 15 minutes before placing the eggs in the vial.

(10) Pour a small quantity of hot paraffin over the raw end of the plug. (Pl. 22, *I*). This precaution prevents the growth of bacteria and fungi.

The plugs are now ready for the reception of the codling moth egg (black-spot stage). The following materials and methods are employed:

Materials

(1) A large supply of codling moth larvae, cocooned in corrugated paper. In order to insure the issuance of moths when needed, the supply of overwintering larvae should be held in cold storage at about 32° F.

(2) Screen cages, 4 feet wide by 2 feet high by 2 feet deep, with 14-mesh wire screen tacked to the inside of the wooden frame so that no wood is exposed. The covering of the frame with screen causes the moths to deposit practically all eggs on sheets of wax paper.

(3) Wax paper (ordinary wrapping paper obtained in rolls 12 inches wide by 40 feet in length). A full-width sheet on which the moths will oviposit freely is placed vertically along the top edge of the back side of the cage. The back side of the cage should be toward the light of greatest intensity.

(4) Scissors and tweezers.

Method

A considerable number of moths is usually required if a large number of eggs is desired. In general, we have maintained in the cage a moth population of from 200 to 300.

Toxicological test against the codling moth: *J*, incubation of codling moth eggs in a battery jar; *K*, cutting out eggs deposited on wax paper; *L*, transfer of egg to vial containing apple plug; *M*, holding rack for completed vials. See plate 23.

The wax paper with the eggs should be removed daily and the sheets should be cut into smaller pieces and placed during the incubation period in a glass battery jar with moist sand. (Pl. 23, *J*). In the summer season approximately 4 to 6 days are required for the eggs to reach the black-spot stage. On about the fifth day, or when the black-spot stage has been reached, the individual egg should be cut out with a pair of scissors. (Pl. 23, *K*). Each piece of paper bearing an egg should be about 0.5 centimeter square. One egg should thus be prepared for each plug. (Pl. 23, *L*).

The final steps in completing the plugs are as follows:

(1) The egg on the small piece of wax paper is picked up with a pair of tweezers. With the egg side away from the glass, the paper should be placed in contact with the paraffin coat on the side of the vial just

above the apple. With this procedure there can be no question as to the larva's being newly hatched. The importance of using a larva fresh in the strictest sense can hardly be overemphasized, as the older a larva is the smaller will be its chance of having enough vitality to enter the fruit.

(2) Cover the vial with a circular piece of sheeting cloth and fasten it in place with a rubber band.

(3) Set the plugs aside in a holder (Pl. 23, *M*) until time for examination. The plugs should be protected from the sun.

(4) At the time of examination remove the covers and examine the plugs for the number of entrances, mortalities, and stings. These results should be scored in a manner similar to that used in the tables presented in this paper.

Care of vials used in toxicological test against the codling moth: *N*, cleaning vial; *O*, wiping vial. See plate 23.

The vials can be readily cleaned by immersing them in gasoline (Pl. 23, *N*) and then rinsing them in hot soapy water, followed by hot water, and finallv wiping them with cheesecloth. (Pl. 23, *O*).

It is estimated that one person can test 100 larvae in a period of 4 hours.

The following tables give the results of experimental work:

TABLE 1. DATA RELATIVE TO THE ENTRANCE OF CODLING MOTH LARVAE IN UNSPRAYED FRUIT, USING THE APPLE-PLUG METHOD, 1931

Date experiment started	Number of larvae	Number of larval entrances	Number of stings	Percentage of larval entrances
Aug. 1	45	43	1	95.5
Aug. 3	30	26	3	86.7
Aug. 4	20	17	1	85.0
Aug. 5	30	28	0	93.3
Aug. 6	28	26	0	92.8
Aug. 14	20	18	1	90.0
Aug. 17	30	30	0	100.0
Aug. 18	17	17	0	100.0
Aug. 20	17	14	3	82.3
Aug. 22	26	26	0	100.0
Sept. 3	48	46	0	95.8
Sept. 4	29	28	0	96.5
Sept. 9	30	30	0	100.0
Sept. 10	40	40	0	100.0
Sept. 19	20	18	0	90.0
Total	430	407	9	Avg. 94.6

It will be noted in Table 3 and in Figure 36 that variations in the percentage of larval entrance were found in each experiment. Two factors that may cause these variations are in constant operation: (1) Spot coverage of spray and (2) individual differences in the behavior of the

TABLE 2. DATA RELATIVE TO THE ENTRANCE OF CODLING MOTH LARVAE IN UNSPRAYED FRUIT, USING THE APPLE-PLUG METHOD, 1932

Date experiment started	Number of larvae	Number of larval entrances	Number of stings	Percentage of larval entrances
Aug. 9	113	99	3	87.6
Aug. 10	42	41	0	97.6
Aug. 11	98	97	1	99.0
Aug. 15	16	15	0	93.7
Aug. 17	31	31	0	100.0
Aug. 18	61	58	0	95.1
Aug. 19	19	19	0	100.0
Aug. 20	44	44	0	100.0
Aug. 22	40	38	0	95.0
Aug. 23	19	18	0	94.7
Aug. 24	60	55	1	91.7
Sept. 8	51	46	0	90.2
Sept. 9	32	31	0	96.9
Sept. 14	76	72	0	94.7
Sept. 15	25	25	0	100.0
Sept. 16	50	46	0	92.0
Sept. 17	25	22	0	88.0
Sept. 20	53	51	0	96.2
Sept. 22	22	18	1	81.8
Total	877	826	6	Avg. 94.2

larvae during the pre-entrance period. Both of these factors merge into the element of chance with respect to the quantity of poison that adheres to the mouth parts and is consumed during the process of ingestion.

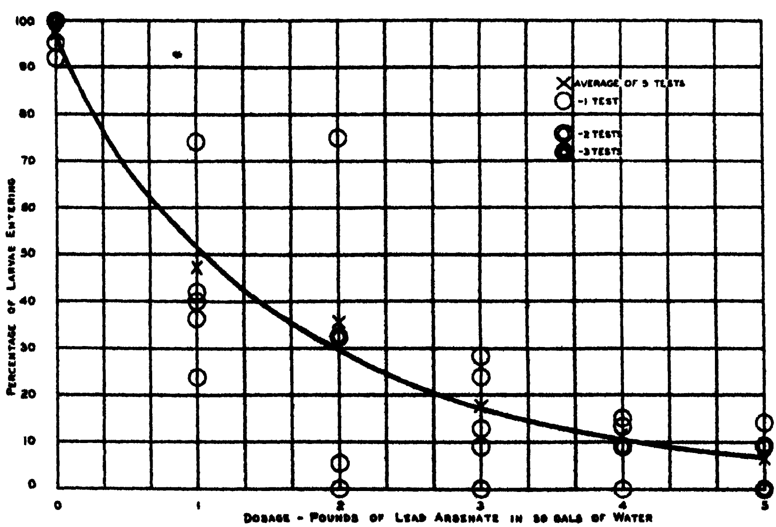


FIG. 36.—Relation of dosage of lead arsenate to percentage of codling moth larvae entering sprayed and unsprayed apple plugs.

TABLE 3. DATA RELATIVE TO THE ENTRANCE OF CODLING MOTH LARVAE IN UNSPRAYED AND SPRAYED FRUIT-DOSAGE TEST WITH LEAD ARSENATE, USING THE APPLE-PLUG METHOD 1932

Date experiments started	Lead arsenate 1 to 50				Lead arsenate 2 to 50				Lead arsenate 3 to 50			
	No. of larvae	No. of larval entrances	No. of stings	Percentage of larval entrances	No. of larvae	No. of larval entrances	No. of stings	Percentage of larval entrances	No. of larvae	No. of larval entrances	No. of stings	Percentage of larval entrances
Aug. 17	31	13	6	41.9	31	10	7	32.2	31	4	3	12.9
Aug. 18	31	23	3	74.2	28	21	2	75.0	32	9	11	28.1
Aug. 22	21	5	1	23.8	19	1	1	5.3	21	5	1	23.8
Aug. 23	11	4	0	36.4	9	0	4	0.0	11	0	1	0.0
Aug. 24	10	4	2	40.0	25	8	2	32.0	11	1	1	9.1
Total or Average	104	49	12	47.1	112	40	16	35.7	106	19	17	17.9
	Lead arsenate 4 to 50				Lead arsenate 5 to 50				Check			
Aug. 17	33	5	5	15.1	31	3	7	9.7	31	31	0	100.0
Aug. 18	30	4	7	13.3	31	0	11	0.0	28	28	0	100.0
Aug. 22	22	2	0	9.1	21	3	0	14.3	22	21	0	95.4
Aug. 23	11	1	0	9.1	11	0	0	0.0	8	8	0	100.0
Aug. 24	11	0	0	0.0	11	1	0	9.1	25	23	0	92.0
Total or Average	107	12	12	11.2	105	7	18	6.7	114	111	0	97.4

NAPHTHALENE AS A FUMIGANT FOR THE IMMATURE STAGES OF CLOTHES MOTHS AND CARPET BEETLES

By Glenn W. Herrick and Grace H. Griswold, *Cornell University*

ABSTRACT

Naphthalene, in the form of flakes and of moth balls, has been used as a fumigant for the immature stages of clothes moths and carpet beetles in a series of experiments extending over a period of several months. Naphthalene flakes at the rate of from 2 to 3 ounces to 5 cu. ft. proved toxic to the eggs and larvae of clothes moths when confined, for a sufficient length of time, in a tight trunk or in a box. Moth balls at the rate of 8 ounces to 5 cu. ft. proved toxic to the larvae of clothes moths when confined in a tight box for a considerable period of time. The results with the immature stages of carpet beetles were only partially satisfactory.

The authors, in continuation of their work with fumigants for the immature stages of clothes moths and carpet beetles, have, for the past year, been conducting a series of experiments to determine the toxic effect of naphthalene on the eggs and larvae of these household pests. In these investigations over 500 larvae and 278 eggs of the clothes moth and 170 larvae of carpet beetles have been used. The experiments have been carried out at ordinary room temperatures, recorded on a maximum and minimum thermometer. A thermograph was not considered practical because each experiment had to run for a considerable period of time. It seemed desirable to determine the effect of naphthalene on the immature stages of these common pests under conditions similar to those of an average household. The moth concerned in these experiments was the common webbing clothes moth, *Tineola bisselliella.* The carpet beetles were the black one, *Attagenus piceus*, and the varied species, *Anthrenus verbasci.*

Types of Fumigation Chambers.—Some of the tests were conducted in an ordinary flat-topped, box trunk. It is an old one, yet is tight and in good repair. It contains just about 5 cubic feet. Other tests were conducted in a galvanized iron box (30 inches long, 18 inches wide and 16 inches deep) containing 5 cubic feet. It is fitted with a cover having a flange on the edge, ½ inch wide, which fits into a gutter running around the top edge of the sides and the ends. This box forms a very tight receptacle, probably somewhat nearer air-tight than the trunk.

Types of Larval Cages.—In all of the experiments the larvae were confined in cylindrical pasteboard cartons, 3¼ inches in diameter and 1⅝ inches in depth. Circular openings, 2 inches in diameter, were cut in the tops and the bottoms of the cartons and, in addition, rows of small holes were punched around the sides. Pieces of fine cheese cloth

were pasted securely over all of the openings. In order to make conditions normal for the insects, squares of flannel and pieces of feathers were placed in the cages. To prevent overcrowding, only five larvae were put in each container. This type of cage has proved very satisfactory for confining larvae during fumigation experiments.

Determination of Results.—In every case the cartons containing the larvae were removed at the end of the fumigation and allowed to remain undisturbed for one week. At the end of this period the five larvae in each carton were carefully examined for signs of life. The checks consisted, in each instance, of similar cartons, each containing five larvae and a similar supply of food. The check larvae, in their cartons, were placed in a cupboard in the same room in which the fumigation was conducted, and were allowed to stand for the same length of time as those undergoing fumigation.

Explanation of the Tables.—The results of the fumigations can best be given by organizing the data in tabular form. The following five tables include the experimental data in a brief, concise manner and need very little explanation. In every case the trunk or the box was filled about two-thirds full of clothing. The pasteboard cartons containing the larvae were placed in the middle layer of this clothing and always wrapped in the folds of a garment. Thus the cartons were well buried among the clothing.

Table 1. Effect of Naphthalene Flakes on Larvae of the Webbing Clothes Moth When Confined in a Galvanized Iron Box or in a Trunk

Amt used in grams	Container	How placed	Time in days	Amt. evap. in grams	Temp. (F.)	Number larvae used	Results* Dead	Results* Not dead	Checks* Dead	Checks* Not dead
85.02	Box	Tin	20	——	———	10	10	0	2	7-a 1-m
170.04	Box	Tin	12	3.60	61°–81°	10	9	1-a	—	——
56.68	Box	Tin	14	3.98	75°–82°	20	20	0	0	4-a 1-m
56.68	Box	Tin	14	3.58	68°–80°	20	17	2-a 1-f	2	2-a 1-m
85.02	Box	Tin	21	2.52	66°–72°	25	22	2-a 1-m	2	7-a 1-m
85.02	Trunk	Tin	21	6.32	70°–75°	30	17 1-p	8-a 4-m	4	5-a 1-m
85.02	Trunk	Loose	14	16.34	70°–75°	10	10	0	1 2-p	7-a
85.02	Trunk	Loose	21	20.82	66°–71°	25	25	0	1	8-a 1-m
113.36	Trunk	Loose	14	21.36	68°–78°	30	30	0	1	9-a
85.02	Trunk	Loose	21	15.50	62°–73°	40	40	0	1	9-a
85.02	Trunk	Loose	14	17.00	54°–70°	50	49	1-a	1-p	14-a

*a, active; f, feebly alive; m, missing; p, killed by parasites.

In Table 1 the naphthalene in the first six fumigations was placed each time in a shallow pie tin which was set on top of the clothing the last thing before closing the lid. In the last five fumigations the flakes were scattered among the different layers of clothing, both below and above the cartons containing the larvae, but never in direct contact with them.

It will be noted that the naphthalene, when placed in a pie tin, did not always kill all of the larvae, although the results were good, except in the 6th fumigation where 30 larvae were used of which 8 remained alive and active. This particular experiment was conducted in the trunk which is probably not as tight as the box. In every case in which the flakes were scattered among the clothing, all of the larvae were killed, except a single individual in the last lot of 50. These results are certainly gratifying. It will also be noted that 3 ounces of flakes to 5 cubic feet, allowed to remain for a period of from 2 to 3 weeks, is effective under the conditions described. Evidently the flakes, when scattered, volatilize more rapidly than when massed in a receptacle. Thus the gas probably becomes more concentrated in the container and consequently more effective in destroying the larvae.

Naphthalene appears to act slowly on the larvae for they remain active some days after the fumigation is begun. When the cartons were opened at the close of each experiment it was noted that a considerable amount of webbing was present on the pieces of flannel. Often the larvae were found enclosed in heavily spun cases.

TABLE 2. EFFECT OF MOTH BALLS ON LARVAE OF THE WEBBING CLOTHES MOTH WHEN CONFINED IN A GALVANIZED IRON BOX

Amt. used in grams	Container	How placed	Time in days	Amt. evap. in grams	Temp. (F.)	Number larvae used	Results* Dead	Results* Not dead	Checks* Dead	Checks* Not dead
226.72	Box	Loose	21	25.72	64°–82°	20	16	1-a, 3-m	0	5-a
226.72	Box	Loose	28	23.12	67°–77°	40	40	0	2	7-a, 1-m
226.72	Box	Loose	28	4.40	68°–75°	50	49	1-m	10-p	5-a

*a, active; m, missing; p, killed by parasites.

In Table 2 are presented the brief results of three fumigations of clothes moth larvae with so-called "moth balls"[1] purchased at a 5 and 10-cent store. The results were rather surprising and significant. It will be noted that, out of the 110 larvae used in the experiments, only a

[1]Dr. L. R. Streeter, chemist of the N. Y. State Agric. Expt. Station at Geneva, very kindly tested the moth balls used in the experiments. He says, "They are pressed naphthalene crystals, melting point 79° to 80° C., same as for pure naththalene."

single individual was found alive and active after an exposure of from 3 to 4 weeks. Unfortunately four larvae were missing and could not be accounted for. Very small quantities of the material in the moth balls volatilized, even through the long period of four weeks.

TABLE 3. EFFECT OF NAPHTHALENE FLAKES ON EGGS OF THE WEBBING CLOTHES MOTH WHEN CONFINED IN A GALVANIZED IRON BOX OR IN A TRUNK

Amt. used in grams	Container	How placed	Time in days	Amt. evap. in grams	Temp. (F.)	Number eggs used	Results* Hatched	Results* Not hatched	Fertility
56.68	Box	Tin	14	3.58	68°–80°	90	0	90	Fertile
85.02	Trunk	Tin	21	6.32	70°–75°	5	0	5	Fertile
85.02	Trunk	Loose	21	20.82	66°–71°	54	0	54	Fertile
85.02	Trunk	Loose	21	15.50	62°–73°	129	0	127 2-m	Fertile

*m, missing.

Little need be said of Table 3. A brief glance will show that all of the eggs in the four experiments listed were killed by the naphthalene whether it was massed in a tin or scattered loosely among the clothing. The eggs used in these experiments were laid by individual females, each confined in a separate vial with a small piece of flannel. Eggs laid by a moth on one day were used in the fumigation experiments, while eggs laid by the same moth on the following day were retained as checks. Wherever eggs, kept as checks, failed to hatch, it was assumed that they were not fertile. Therefore, no eggs laid by a female, whose eggs failed to hatch in the check, were considered in any of the experiments. If the eggs of a moth in the check hatched, it seems fair to assume that the fumigated eggs, laid by the same female, were also fertile. While undergoing fumigation the eggs were in uncorked vials placed in an open wire basket. This basket, containing the vials of eggs, was wrapped in one of the garments with which the box or the trunk was filled.

TABLE 4. EFFECT OF NAPHTHALENE FLAKES ON LARVAE OF THE BLACK CARPET BEETLE WHEN CONFINED IN A GALVANIZED IRON BOX OR IN A TRUNK

Amt. used in grams	Container	How placed	Time in days	Amt. evap. in grams	Temp. (F.)	Number larvae used	Results* Dead	Results* Not dead	Checks* Dead	Checks* Not dead
85.02	Box	Tin	21	2.52	66°–72°	20	1	19-a	0	10-a
85.02	Trunk	Tin	21	6.32	70°–75°	20	0	20-a	–	—
226.72	Box	Loose	14	——	70°–78°	15	13	2-a	0	5-a
85.02	Trunk	Loose	21	20.82	66°–71°	20	17	3-a	0	10-a
85.02	Trunk	Loose	14	19.02	68°–78°	20	19	1-a	0	5-a

*a, active.

It is evident from the data in Table 4 that naphthalene is not as toxic to the larvae of the black carpet beetle, *Attagenus piceus*, as it is to the

larvae of the clothes moth. In the first two fumigations, in which 3 ounces of the flakes were placed in a tin and allowed to remain three weeks in a closed receptacle, only a single larva, out of a total of 40, was killed. On the other hand, when the flakes were loosely scattered among the clothing, the results were much more satisfactory. Out of a total of 55 larvae in the last three experiments, 49 were killed. It is of interest to note that 8 ounces of the flakes were no more effective than 3 ounces. It seems certain that the larvae of the black carpet beetle are more resistant to the toxic effect of the naphthalene gas than are the larvae of clothes moths.

TABLE 5. EFFECT OF NAPHTHALENE FLAKES ON LARVAE OF THE VARIED CARPET BEETLE WHEN CONFINED IN A GALVANIZED IRON BOX OR IN A TRUNK

Amt. used in grams	Container	How placed	Time in days	Amt. evap. in grams	Temp. (F.)	Number larvae used	Results* Dead	Results* Not dead	Checks* Dead	Checks* Not dead
226.72	Box	Loose	14	——	70°–78°	15	4	11-a	0	5-a
85.02	Trunk	Loose	21	15.50	62°–73°	20	1	17-a 2-m	0	5-a

*a, active; m, missing.

The data in Table 5, although brief, indicate that the larvae of the varied carpet beetle, *Anthrenus verbasci*, are more resistant to the naphthalene than are those of the black carpet beetle. It will be noted that, out of a total of 35 larvae fumigated, only 5 were killed, even when the flakes were scattered loosely among the clothing. Although the majority of the larvae were found alive at the end of each experiment, they had certainly been affected, to some extent, by the naphthalene fumes. This was evident when a comparison was made between the activity of the larvae in the fumigated cartons and of the larvae in the check cartons. The larvae in the check cartons ate many holes in the pieces of flannel and feathers which had been provided for food. The fumigated larvae, on the other hand, ate very little.

REMARKS.— It seems clear that naphthalene, in the form of flakes or of moth balls, is toxic to eggs and larvae of the webbing clothes moth. The flakes, when scattered loosely among the clothing, appear to be somewhat more effective than the moth balls. Naphthalene flakes are also toxic to the larvae of carpet beetles, although larvae of the varied carpet beetle appear to be much more resistant to the fumes than are larvae of the common black species.

When the flakes of naphthalene are scattered loosely among the clothing, many of the crystals appear to deliquesce slightly. Such crystals stick, rather persistently, to the garments and are not easily brushed off, especially if the cloth is rough in texture. This annoying

feature can probably be obviated by scattering the flakes between layers of newspapers in order to prevent them from coming in actual contact with the garments.

LOSS IN TOXICITY OF DEPOSITS OF ROTENONE AND RELATED MATERIALS EXPOSED TO LIGHT

By Howard A. Jones, W. A. Gersdorff, and E. L. Gooden, *Bureau of Chemistry and Soils*, and F. L. Campbell and W. N. Sullivan, *Bureau of Entomology, U. S. Department of Agriculture*

Abstract

Rotenone, dihydrorotenone, rotenone hydrochloride, rotenone-bentonite (1:1), rotenone-lampblack (1:1), ground derris root, and powdered derris extract were each made into a paste with water and painted heavily on weighed glass slides. After the deposits had dried, the slides were weighed again. One group of slides was exposed to direct sunlight for ten days during April and May, a second group to sunlight for twenty days, a third group to arc-light for 240 hours, a fourth group of the three pure compounds only, to arc-light for 480 hours, and a fifth group was kept in the dark at room temperatures.

The deposits on these slides were tested against culicine mosquito larvae and goldfish to determine the percentage loss of toxicity resulting from exposure to light. In all cases the exposed deposits were decidedly less toxic than the unexposed and, with one exception, the loss of toxicity increased with increasing exposure.

Rotenone, rotenone-bentonite, derris root, derris extract, and rotenone hydrochloride lost more than half of their toxicity during ten days' exposure to sunlight. Their toxicity was practically destroyed by the exposure to arc-light.

Since dihydrorotenone lost only one-fourth to one-third of its toxicity during the first ten days' exposure to sunlight, it was distinctly more resistant to detoxication during this period than rotenone. However, at the end of twenty days in sunlight and after exposure to arc-light it had lost toxicity to about the same extent as rotenone.

Lampblack markedly reduced the loss of toxicity of rotenone during the first ten days' exposure to sunlight, and prevented further loss during the last ten days. It also gave some protection to rotenone under arc-light. Neither bentonite nor the substances occurring with rotenone in powdered derris root and derris extract protected rotenone from loss of toxicity.

The unexposed powdered derris extract containing about twenty-five per cent rotenone was as toxic to mosquito larvae as pure rotenone.

It was shown that the photochemical decomposition of dry rotenone, which results in loss of its toxicity to insects and fish, does not take place in the absence of oxygen.

Rotenone, which occurs in derris root and cube root, has been tested as a contact and stomach insecticide on a small scale against a number of species of insects (1)[1] and under certain conditions has proved to be

[1]This and certain other references in the present paper refer to a review of information on the insecticidal value of rotenone. Since this review contains information not published elsewhere, care should be taken to attribute the results mentioned to the workers named and not to the author of the review.

highly toxic to some species. Because rotenone is harmless to man and domestic animals when taken by mouth in small quantities (10), it is particularly desirable to ascertain the proper methods for using it for the protection of plants against insect pests. Its value for this purpose is partly dependent on its stability after being sprayed or dusted on plants. Since statements in the literature and our own preliminary tests indicate that rotenone is altered by light, a more thorough study of the effect of light on dry deposits of rotenone was considered necessary.

Review of Literature

The decomposition of rotenone in solution in organic solvents, with accompanying loss of toxicity, has already been demonstrated (4, 7, 12, 14). The fact that dry rotenone may also be changed by light was noted by Durham as early as 1902 (9). Tattersfield and Roach (14) found that crystals of rotenone become yellow when exposed to light. Small-scale tests of rotenone against the codling moth by Newcomer, by Hough, and by Lathrop (1) showed that the spray deposits lost a large part of their originally high effectiveness after several days' exposure. The tests did not demonstrate definitely whether this loss was due to weathering or to chemical change of the rotenone, although the latter was strongly indicated. Experiments by Davidson and by Ginsburg (1) gave similar indications.

Recently Moore (1) has found that fabrics impregnated with rotenone, although resistant to fabric pests when first treated, lose some of this resistance to attack when exposed to light. Fabrics kept in the dark retain resistance to attack. Moore's tests also indicate that light rather than heat is responsible for the effects observed. The tests gave no data on the exact rate of loss of resistance to attack.

Tattersfield (13) has recently shown that dry pyrethrum powders and dusts lose their toxicity rapidly on exposure to light.

Decomposition of Dry Deposits on Glass

Change in Appearance of Rotenone.—Preliminary experiments showed that rotenone, painted on glass slides and allowed to dry, turns yellow after two or three days' exposure to direct sunlight. Similar slides were kept in the dark for a month at 20° C. without change in appearance. Other slides were kept in the dark for about 400 hours at 100° C. Some of these deposits turned slightly yellow and all became slightly more transparent than the checks. These tests confirmed the observations of previous workers that rotenone is changed by exposure to sunlight and showed that heat is not an important factor in the change at the temperatures produced by sunlight.

NATURE OF DECOMPOSITION OF ROTENONE.—As already mentioned, rotenone in solution in organic solvents is oxidized to non-toxic, yellow, decomposition products. By analogy it was thought that the change occurring in dry rotenone deposits on exposure to light was also very probably an oxidation. To decide this point definitely, powdered rotenone was exposed to sunlight in an evacuated tube for about one month. The material was not changed in color. When air was admitted to the tube the powder became deep yellow in color in less than a week of exposure to sunlight. This leaves no doubt that the change occurring when rotenone is exposed to light is an oxidation. It is quite probable that dehydrorotenone and rotenonone are the first products of the dry decomposition just as they are of the decomposition of rotenone in solution.

REGION OF SPECTRUM CAUSING DECOMPOSITION OF ROTENONE.—In an attempt to determine what region of the spectrum causes this photochemical decomposition of rotenone, deposits on glass slides were exposed to a carbon arc-light under various light filters. These tests indicated that the deep violet region is the most effective portion of the visible spectrum in producing the change. From the results of these tests, the ultra-violet region does not appear to be as effective as the visible violet.

CHANGE IN APPEARANCE OF COMPOUNDS RELATED TO ROTENONE.—A deposit of the rotenone-carbon tetrachloride solvate colored much more rapidly than rotenone and at the end of an exposure to seventy hours' sunlight it was deep orange-yellow. Dihydrorotenone, isorotenone, and acetyl rotenone all changed at about the same rate and were lighter in color at the end of the exposure than the exposed rotenone deposits. Dehydrorotenone, originally light yellow, changed to a very deep, golden yellow. Rotenol and dihydrorotenol, white reduction products of rotenone, remained white throughout the exposure. Unfortunately these two materials are much less toxic than rotenone. Deguelin and tephrosin changed from almost white to light or medium yellow in the same period of exposure.

LOSS OF TOXICITY OF DRY DEPOSITS ON GLASS

Deposits of rotenone that were yellowed by sunlight in the preliminary experiments were tested in comparison with pure rotenone against goldfish and against two species of insects,[2] greenhouse whitefly larvae (*Trialeurodes vaporariorum* Westw.) and melon aphids (*Aphis gossypii*

[2]Tests were made by W. M. Davidson, Insecticide Control Division, Food and Drug Administration.

Glov.). It was found that rotenone lost toxicity in proportion to the period of exposure No loss of toxicity was found in the unexposed checks. Exposed dihydrorotenone was also tested against goldfish and appeared to be more resistant than rotenone to loss of toxicity.

The principal toxicological tests, with which the remainder of this paper deals, were undertaken to study more thoroughly the rate of change in toxicity, particularly to insects, and to develop methods of preventing the loss

The materials exposed in these tests were rotenone, dihydrorotenone, rotenone hydrochloride, a mixture of rotenone and bentonite, a mixture of rotenone and lampblack, powdered derris root, and derris extract The dihydrorotenone was used because of the smaller loss in toxicity on exposure, which had been found in preliminary experiments. The chemical structure of rotenone hydrochloride is similar to that of dihydrorotenone, and it was thought that it might also resist change The bentonite and lampblack mixtures were used in an effort to coat the rotenone with a protective material The derris root and derris extract were tried to ascertain whether or not the rotenone might be naturally protected from photochemical change in these products.

Preparation of Materials for Exposure.[3]—*Rotenone:* Two grams of pure crystalline rotenone was dissolved in 100 cc. of acetone and this solution added to four liters of distilled water with continuous stirring Twenty cc. of ten per cent sodium chloride solution were added to this suspension. The rotenone separated quickly as a flocculent precipitate It was washed several times by decantation, filtered by suction, and washed well on the filter with distilled water. The material, dried at 105° C., was pure white. Examination of this precipitated rotenone under the polarizing microscope showed that it consisted of very small non-crystalline particles. The melting point of this material was 159° C.

Dihydrorotenone: Precipated dihydrorotenone was prepared in a similar manner. The dried material was pure white and consisted of non-crystalline particles of about the same size as the rotenone particles. The material had a melting point of 207° C., as compared with 216° C. for pure crystalline dihydrorotenone.

Rotenone hydrochloride: Precipitated rotenone hydrochloride was pure white and composed of particles slightly larger than those in the

[3]Since preliminary experiments had convinced us that the change taking place in the diffused light of the laboratory in the time necessary for the preparations was inconsequential, it was not considered necessary to make the preparations in the dark.

precipitated rotenone. Faint double-refraction was detectable. Its melting point was 190° C., as compared with 193° C. for the original crystalline material.

Rotenone-bentonite mixture: 0.1 gram of the precipitated rotenone previously described was throroughly mixed with 0.1 gram of bentonite.

Rotenone-lampblack mixture: 0.1 gram of the precipitated rotenone was thoroughly mixed with 0.1 gram of lampblack.

Derris root: A sample of derris root (Insecticide Division No. 402) containing 1.4 per cent rotenone and a total carbon tetrachloride extract of 7.6 per cent was used in these tests. The root was ground to pass a 170-mesh sieve.

Derris extract: About 80 grams of the ground derris root was completely extracted, at room temperature, with acetone. The liquid acetone extract, amounting to about 400 cc., was added with stirring to four liters of distilled water, after which about 200 cc. of ten per cent sodium chloride solution were also added. The curdy precipitate which soon settled was washed three times by decantation. It was filtered by suction, washed well with water, and dried for several days at room temperature. The product was a perfectly dry, light tan, impalpable powder. Under the microscope it was found to be entirely non-crystalline and composed of particles smaller in size than those of the precipitated rotenone. When analyzed by the carbon tetrachloride method (11) this material was found to contain 23.6 per cent rotenone. There is little doubt that some of the extractive material was lost in the washing of this material, since the wash waters were somewhat cloudy. However, the object was not to obtain a quantitative extract but to produce a dry powdered material which might be considered to contain the major portion of the ingredients of the extract.

Each of these materials was made to a paste with water as in the preparation of the preliminary exposure deposits, using 200 mg. of material to 4 cc. of water, except the derris root, in which case 200 mg. were mixed with 2 cc. of water. The pastes were "painted" on previously weighed lantern slide cover glasses (3¼" x 4") by means of a camel's-hair brush. A narrow margin was left around the edge of the slide to prevent loss in handling. An effort was made to coat the derris root slides more heavily than the others because of the low rotenone content of this deposit. The deposits were allowed to dry thoroughly in the dark and the slides weighed again to determine the weight of the coating. The weights of the deposits are given in Table 1.

One set of these slides was exposed to sunlight for ten days and another set for twenty days. They were covered by a thin sheet of cello-

phane to keep off dust. The exposure was made during the later part of April and the early part of May, for the period from 8 A. M. to 5 P. M., on clear days only. Two other sets were exposed to a carbon arc at a distance of about one foot for 240 and 480 continuous hours, respectively.[4] The first of these periods was equivalent to two or three months' outdoor exposure, the second to at least the time of the longest spraying schedule used in orchard spraying. Only the three pure compounds were given the 480-hour exposure. The slides of the remaining set were kept in the dark at room temperature as checks.

At the end of the exposure periods the deposits were examined and reweighed, and toxicological determinations were made on both insects and fish. The per cent change in weight of the deposits is shown in Table 1 The appearance of the deposits and their loss in toxicity are discussed in a subsequent part of this paper.

METHOD OF DETERMINING LOSS OF TOXICITY TO MOSQUITO LARVAE.—The small quantities of exposed deposits available (see Table 1) made necessary the adoption of special procedures for determining the loss of toxicity. All exposed deposits and the unexposed check deposit in one series were tested simultaneously in water at one and the same concentration against a series of known concentrations of the pure compound or substance. The concentration of the deposits in water was made the same as that of the highest concentration of the original substance. In the rotenone series, for example, all the deposits exposed to sunlight and arc-light and the unexposed check deposit were tested simultaneously against five concentrations of rotenone that covered the range of effect to be expected from the deposits. These tests were repeated every day until reliable mean figures were obtained for the survival period of 50 per cent of the larvae. The determiniation of loss in toxicity of the exposed deposits or "unknowns" was based on a ratio of concentrations of "knowns" and "unknowns" causing the same survival periods. The method by which the determination was made is described at the end of this section.

Since rotenone and related compounds are very slightly soluble in water, it was necessary to add acetone solutions of them to water in order to dissolve the substances quickly or to produce finely divided suspensions. In preliminary tests it was found that the larvae would tolerate acetone in water at 1:330. A concentration of 1:660 was adopted and used in all tests to give a margin of safety. No mortality occurred in dozens of acetone checks that were run during the course of the work.

[4]The slides exposed to the arc attained a temperature of about 57° C.

In order to make up acetone solutions of the deposits at a known concentration, it was necessary to put the entire deposit on a slide into a known quantity of acetone. Preliminary tests on acetone tolerance

TABLE 1 WEIGHT OF EXPOSED DEPOSITS

	Insect tests		Fish tests	
	Orig. weight	Gain or loss	Orig. weight	Gain or loss
Material and exposure	mg.	%	mg.	%
Rotenone—				
Sunlight, 10 days	17.2	— 2	15.5	—11
20 days	18.9	— 6	16.5	— 2
Arc light, 240 hours	19.9	—56	19.4	—66
480 hours	17.9	—78	13.3	—71
Unexposed to light	13.2	+ 9	16.3	+ 7
Dihydrorotenone—				
Sunlight, 10 days	15.8	— 4	16.7	— 5
20 days	15.9	None	10.3	None
Arc light, 240 hours	11.7	—64	19.9	—67
480 hours	15.0	—81	19.5	—81
Unexposed to light	9.4	+ 7	11.7	+10
Rotenone hydrochloride—				
Sunlight, 10 days	13.7	— 9	10.5	— 9
20 days	10.1	— 5	17.6	— 6
Arc light, 240 hours	18.9	—83	17.4	—76
480 hours	14.4	—83	13.6	—82
Unexposed to light	15.5	+ 6	15.2	+ 7
Rotenone-bentonite mixture—				
Sunlight, 10 days	15.4	+ 4	25.7	— 4
20 days	18.7	+ 4	18.8	— 0.5
Arc light, 240 hours	18.0	—30	12.6	—30
Unexposed to light	17.1	+11	20.2	None
Rotenone-lampblack mixture—				
Sunlight, 10 days	12.9	—32*	17.6	— 8
20 days	17.6	+ 2	15.2	+ 7
Arc light, 240 hours	15.1	—16	14.7	—18
Unexposed to light	13.9	None	16.3	+ 4
Derris root—				
Sunlight, 10 days	38.4	+ 5	36.6	— 3
20 days	65.4	+ 4	44.3	+ 5
Arc light, 240 hours	41.9	—13	67.1	—19
Unexposed to light	47.7	+ 6	51.6	+ 2
Derris extract—				
Sunlight, 10 days	13.8	+ 7	25.1	— 2
20 days	22.1	+ 6	26.5	+ 4
Arc light, 240 hours	20.8	—17	18.7	—28
Unexposed to light	24.0	+ 6	29.2	— 0.3

*Portion of glass slide chipped off.

and on the effect of the original materials showed that the deposits would have to be put into less than 5 cc. of acetone and generally into about 2 cc. Such small volumes could not be used quantitatively to remove the deposits. Consequently each deposit was scraped from the

slide, the slide was rinsed with a larger volume of acetone, and the deposit and acetone were washed into a test tube. The acetone in the tube was then evaporated off, leaving most of the deposit as a cake at the bottom of the tube. A sample of the original material used in preparing the deposit was dissolved or suspended in acetone and evaporated in the same way so that possible loss in toxicity due to this process might be detected in subsequent tests Such preparations were called "evaporated checks."

Solutions or suspensions of the exposed deposits and of the unexposed and evaporated checks were prepared for the tests by addition of acetone by weight to the vacuum evaporated residues in the test tubes. The weight of acetone to be added was calculated on the basis of the original weight of the deposits on the slides. Since portions of some of the deposits were lost by volatilization during exposure and since some of the decomposition products were insoluble in acetone, the actual concentrations of the solutions of the exposed deposits were in every case less than those calculated. The volatilized and insoluble portions were regarded as having lost all their toxicity and were treated in the calculations as if they had been inert in solution. The acetone solutions of the original materials were made up by half-and-half dilution from the solution of the highest concentration. The volume of each of these known solutions was made 2 cc., which was about the average volume of the unknown solutions.

The evaporated residues of a series were prepared a few days before the beginning of the tests of that series, and acetone was added to the tubes a few hours before the first tests. All tubes were stoppered with foil-covered corks and placed in a refrigerator to retard evaporation of acetone and to keep them in the dark when they were not in use. A tube was opened only for a few seconds at a time while the dose was being withdrawn. The period during which the tubes of a series were used did not exceed ten days. The tubes of the rotenone series were weighed from day to day to determine the rate of evaporation of acetone. Although about 5 per cent of the initial weight of the solutions was lost in four days, it was not considered necessary to correct the concentration by addition of acetone because the relative concentration of the more important solutions remained the same.

Eggs laid by mosquitoes at large were collected daily on the grounds of the Takoma Park, Md., station. Methods of rearing and counting the larvae and of transferring them from one container to another are described elsewhere (3). Whenever possible, larvae in the early part of the fourth stadium were chosen for the tests. Larvae in the

third stadium and those near pupation could not be entirely avoided, however. Owing to the very distinct influence of age of the larvae on susceptibility and the impossibility of always selecting larvae of the same average stage of development, it was necessary to test the known solutions with every test of the unknown. Since the larvae to be used for a day's work were mixed before counting them out and since knowns and unknowns were always tested simultaneously, it did not matter, for the purpose of this work, what species of larvae was used. However, several samples of adults were sent to Alan Stone, Bureau of Entomology, for identification. *Culex pipiens* L. and *C. territans* Walk. were found, in two cases mixed in the same sample.

All tests, except those of the rotenone series, were made in 125-cc. Erlemeyer flasks containing 100 larvae in 100 cc. of distilled water, at least four tests of each material being made. The tests of the rotenone series were made in test tubes containing 10 larvae in 10 cc. of distilled water, and in this series 14 tests were made of each deposit. Since the former method differed little in technic and not at all in principle from the latter, the following description will be confined to the flask method.

A capillary pipette (2) having a bore of 0.622 mm. was used to withdraw the dose of acetone solution (0.152 cc.) from the tubes and to add it to the water containing the larvae in the flasks. Immediately after the addition of the solution the contents of the flask were mixed and it was placed in a water bath at 29.3 ± 0.1° C. The time of dosing was recorded

Long before the larvae were killed by rotenone or related compounds, abnormal behavior was noted in treated flasks In the checks the larvae tended to congregate in a ring at the surface about the walls of the flask. Some larvae moved about at or below the surface without wriggling, as if propelled by the vibrating mouth parts. In the treated flasks the larvae tended to distribute themselves uniformly under the surface of the water and did not glide about. Wriggling movements through the water were frequent. As the effect of the poisons progressed, the larvae became less active. Disturbances that sent all check larvae wriggling to the bottom had no effect on most of the treated larvae, which remained suspended from the surface. Still later a few of the treated larvae, usually the smallest in the flask, were seen lying dead on the bottom. At this point the flask was twirled, throwing all larvae beneath the surface. Those that were dead or very weak remained on the bottom, and as the water came to rest, they were forced by the currents toward the center. Here they piled up and were easily removed by pipette to be counted. The flasks were twirled from time to time, until 40 to 45 dead

or moribund larvae had been thrown down, removed, and counted. Then the flasks were twirled, and the larvae that came down were counted without removing them from the flask until the 50th larva was down. The time was then recorded as the end point.

The method used to determine loss of toxicity is illustrated in Figure 37. In the case of rotenone-bentonite, for example, the effects of four

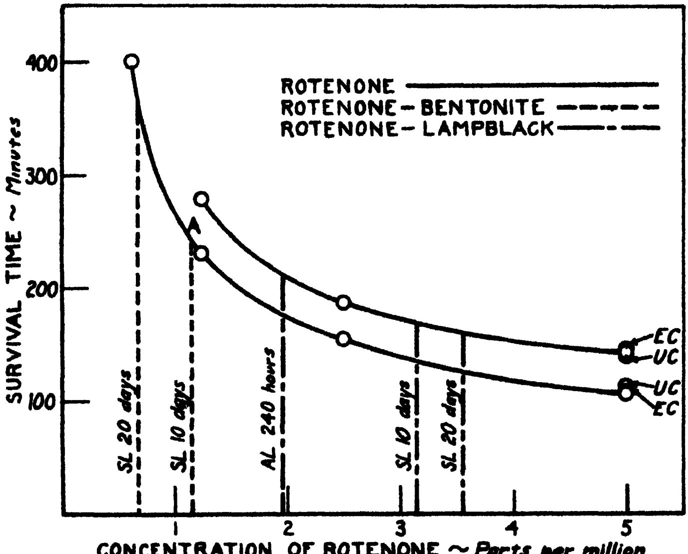


FIG. 37.—Curves showing graphical method used for estimating loss in toxicity to culicine mosquito larvae of rotenone mixed with bentonite and with lampblack, when exposed to light. SL = sunlight, AL = arc-light, EC = evaporated check, UC = unexposed check deposit.

concentrations of rotenone ranging from 0.625 to 5 parts per million[5] in water were compared with those of the exposed deposits and the unexposed and evaporated checks at 5 parts of rotenone or its decomposition products per million. The lower curve shown in Figure 37 represents the effect of rotenone over the range of concentrations mentioned above. The survival time in the unexposed check (UC) and the evaporated check (EC) was practically the same as in rotenone at 5 parts per million, as it should be if rotenone in the check deposits retained its toxicity. Since the survival time in deposits exposed to sunlight was much greater, some of the toxicity of rotenone in the mixture must have

[5]The term "parts per million" as used in this paper refers to parts by weight of the material tested to a million parts by volume of the final dilution.

been lost. When, for example, the survival period for "sunlight 10 days" is located at A on the rotenone curve and a line is dropped to the X-axis, it is seen that the deposit had an effect equivalent to that of rotenone at 1.16 parts per million. Since it was tested at 5 parts of rotenone or its decomposition products per million, it therefore retained 1.16/5, or 23 per cent of its toxicity, or had lost 77 per cent of its toxicity. This example might be stated in general terms as follows: Loss of toxicity in per cent equals $100 - \left(\frac{100\ C}{c}\right)$ where "C" is the concentration of original material equivalent in effect to that of the exposed deposit and "c" is the calculated concentration of exposed deposit as tested.

The upper curve in Figure 37 is also for rotenone. Data for it were obtained at the same time that rotenone-lampblack deposits were tested. The fact that it does not coincide with the lower curve, owing to greater average resistance of the larvae, illustrates the necessity of testing the original material simultaneously with the unknowns.

It should be pointed out that the precision of the determination of per cent loss in toxicity by this graphical method depends on the portion of the rotenone curve upon which the survival periods for the unknowns happen to fall. At both ends of the curve when it begins to approach a straight line the precision is low; it is greatest where the curvature is greatest. It would have been desirable, therefore, to have used concentrations of the unknowns that would have given survival periods falling upon the bend of the rotenone curve. However, the small quantities of deposits available did not permit the preliminary experimentation necessary for this purpose.

Method of Determining Loss of Toxicity to Goldfish.—The method of determining toxicity to goldfish has been described in a previous paper by one of the authors (5). As in the insect tests, the ratio of concentrations of known and exposed solutions that killed in the same time was used to estimate loss in toxicity.

The goldfish used in the tests were from the same lot and weighed from 2 to 3 gm., averaging 2.4 gm. Twelve fishes were used in each test until the diminishing stock necessitated reduction in this number. The tests were made at a temperature of 27.0° ± 0.2° C.

The exposed materials were scraped from the slides and dissolved in acetone, as in the preparation of materials for the insect tests. However, in this case the material was washed directly into small volumetric flasks and made to volume without evaporation. The tests were made within a few hours after the solutions were prepared.

The determination of the proper concentration of the acetone solutions of the exposed materials usually required trial tests at one or more concentrations. Whenever possible a concentration was chosen that caused the mean survival time of the fishes to fall within the limits

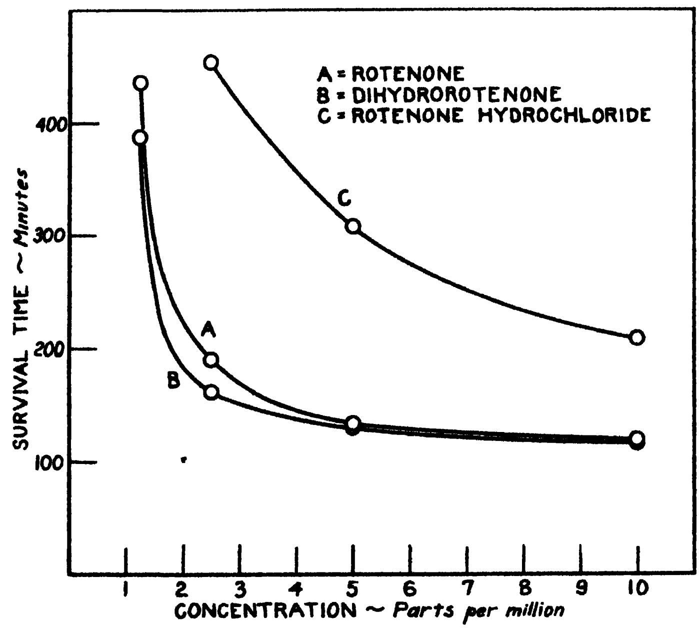


FIG. 38.—Relative toxicity of rotenone, dihydrorotenone, and rotenone hydrochloride for culicine mosquito larvae.

represented by that portion of the survival time-concentration curve having the greatest curvature. In a few cases, in which the quantity of material was sufficient for only one or two tests, long survival periods that did not fall in the bend of the curve had to suffice.

Relative Toxicity of Rotenone, Dihydrorotenone, and Rotenone Hydrochloride.—The relative toxicity of these compounds was determined by the two methods outlined in order to ascertain at what concentrations the exposed deposits of these materials should be tested.

The mean results of two series of tests on mosquito larvae are shown in Table 2 and are plotted in Figure 38. Dihydrorotenone appears to be slightly more toxic than rotenone to mosquito larvae. Rotenone hydrochloride is much less toxic than rotenone.

Owing to the variation in susceptibility of mosquito larvae from day

to day, previously mentioned, the curves of Figure 1 were not used for the determination of "C," but the data for such curves were obtained simultaneously with the tests of each series of exposed materials.

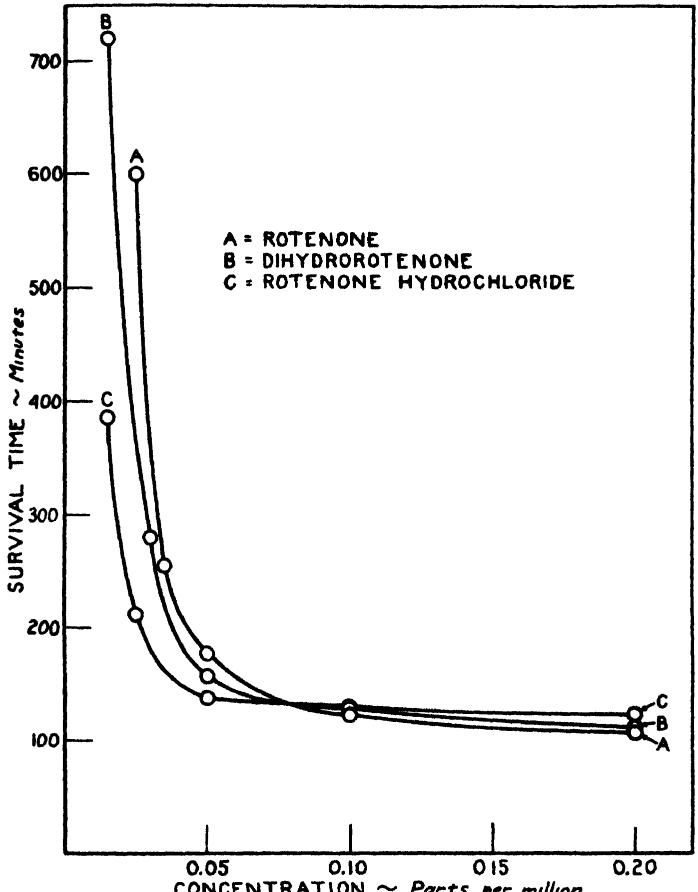


FIG. 39.—Relative toxicity of rotenone, dihydrorotenone, and rotenone hydrochloride for goldfish.

The data obtained in the tests of the three pure compounds on goldfish are also given in Table 2[6] and are plotted in Figure 39. Since goldfish have been found to vary less than mosquito larvae in susceptibility, the curves established by these data were used to determine "C."

[6]Similar data on these same materials are contained in previous papers by one of the authors (6, 8).

RESULTS OF TESTS OF EXPOSED DEPOSITS.—*Rotenone:* As in previous tests, the deposits of rotenone exposed to sunlight became yellow in color. At the end of ten days the material was light yellow. The deposits exposed for longer periods were progressively deeper in color and

TABLE 2. COMPARATIVE TOXICITY OF ROTENONE, DIHYDROROTENONE, AND ROTENONE HYDROCHLORIDE

Material	Insect tests: Concentration at which tested (parts per million)	Insect tests: Survival time (min.)	Fish tests: Concentration at which tested (parts per million)	Fish tests: Survival time (min)
	10.0	120	0.20	107
	5.0	134	0.10	123
Rotenone.	2.5	190	0.050	177
	1.25	436	0.035	255
			0.025	600
	10.0	116	0.20	111
	5.0	130	0.10	128
Dihydrorotenone.......	2.5	161	0.050	158
	1.25	387	0.030	280
			0.015	720
	10.0	209	0.20	124
	5.0	308	0.10	130
Rotenone hydrochloride	2.5	454	0.050	138
			0.025	212
			0.015	386

were more transparent in appearance than the coatings exposed for only a short time. When examined under the microscope the deposit exposed to the sunlight for twenty days, and those exposed to the arc-light, appeared to have partially melted, and the particles were fused together. The deposits exposed to the arc lost almost three-fourths of their weight. The material kept in the dark did not change in appearance or weight.

As an example of the data obtained in determining the loss in toxicity of the exposed deposits, the mean results of the tests on the rotenone deposits against both insects and fish are given in Table 3.

According to the insect tests, rotenone exposed to sunlight lost about two-thirds of its toxicity in ten days and thereafter the toxicity steadily decreased. It appears to have lost a greater proportion of its toxicity to fish in ten days. The check deposit kept in the dark and the evaporated check showed practically no loss of toxicity to mosquito larvae. However, this result is somewhat uncertain because the tests were made at concentrations on the flat portion of the curve. The tests with goldfish indicated some loss in toxicity in the deposits kept in the dark, although in preliminary experiments, with similar deposits, no loss had been detected.

Dihydrorotenone: The appearance of the dihydrorotenone deposits was very much the same as that of the rotenone deposits. The dihydrorote-

none, however, did not change perceptibly in color during the last ten days' exposure to sunlight. Under the microscope these deposits did not show the marked appearance of melting noted with the rotenone, only small parts of the deposits showing this phenomenon. Dihydrorotenone

TABLE 3. LOSS IN TOXICITY OF ROTENONE DEPOSITS EXPOSED TO LIGHT

Insect tests

Exposure	Concentration at which tested (p.p.m.)	Survival time (min.)	Concentration of rotenone corresponding to survival time (p.p.m.)	Loss in toxicity (%)
Not exposed (from stock)	10	121		
	5.0	127		
	2.5	175		
	1.25	>302		
	0.62	>490		
Sunlight—10 days	10	146	3.6	64
Sunlight—20 days	10	167	2.7	73
Arc-light—240 hrs.	22.7	267	1.4	94
Arc-light—480 hrs.	45.5	>366	0.9	98

Fish tests

Exposure	Concentration at which tested (p.p.m.)	Survival time min.	Concentration of rotenone corresponding to survival time (p.p.m.)	Loss in toxicity (%)
	*			
Not exposed (from stock)				
Sunlight—10 days	0.310	154	0.063	80
Sunlight—20 days	0.165	246	0.035	79
Arc-light—240 hrs.	1.94	184	0.048	98
Arc-light—480 hrs.	2.24	449	0.027	99

*Calculations made from curve previously established for rotenone.

lost toxicity much less rapidly during the first ten-day exposure than did rotenone. At the end of twenty days, however, it had lost to about the same extent as rotenone. The deposit kept in the dark showed no change in toxicity either to goldfish or mosquito larvae.

Rotenone hydrochloride: The exposed deposits of rotenone hydrochloride were very similar to the corresponding deposits of rotenone in appearance, and showed very nearly the same loss of toxicity in corresponding periods of time. The unexposed check showed no loss of toxicity to insects, but there was a slight loss of toxicity to fish.

Rotenone-bentonite mixture: The deposits of the mixture of rotenone and bentonite became tan-yellow in color on exposure to light. As might be expected, the deposits exposed to the arc lost only half as much of their weight as did the deposits of pure rotenone under the same conditions. The loss in toxicity of rotenone in the rotenone-bentonite mixture was practically the same as that of the rotenone deposit (Fig. 37).

Rotenone-lampblack mixture: No change in appearance could be noted in the rotenone-lampblack mixtures exposed to light. The deposits exposed to the arc lost an average of only 17 per cent of their weight, or, assuming no loss of lampblack, only 34 per cent of the weight of the rotenone portion of the deposit was lost. This is interesting when considered in conjunction with the fact that this deposit lost less of its toxicity than deposits of the other materials.

The rotenone in the rotenone-lampblack mixture retained its toxicity longer than any of the other materials tested. Although it lost about the same as, or slightly more than, the dihydrorotenone in ten days, it showed no further loss in an additional ten days' exposure (Fig. 37). The unexposed checks showed no loss of toxicity to insects or fish.

Derris root and derris extract: The deposits of derris root darkened slightly and became somewhat more opaque in appearance on exposure to light. Those of the derris extract turned from a light tan to a dull orange in twenty days' exposure to sunlight. The apparent melting was much more noticeable than in the deposits of any of the other materials.

In making toxicity tests of the deposits of powdered root and of total extract it was necessary to use a different series of concentrations owing to the smaller proportion of rotenone present (particularly in the root). Furthermore, toxic substances other than rotenone are present in these materials, and consequently a slightly different method of calculation had to be adopted. As an example of the concentrations employed and the data obtained, the mean results of the tests on the derris extract are given in Table 4.

The checks of derris extract for the mosquito larvae tests were made at concentrations of rotenone ranging from 2.5 to 0.156 parts per million, and the exposed deposits were tested at 2.5 parts per million in terms of the rotenone present in the deposit before exposure. Deposits exposed to the arc-light had almost no effect on the larvae. From the values for the checks a curve was plotted, and the concentrations of extract, in terms of rotenone, corresponding to the survival periods resulting from the exposed deposits, were read from this curve. The loss in toxicity was calculated as before from the ratio of these two concentrations.

In the fish toxicity tests no curve was established for the derris extract. Instead the extract was tested at two concentrations, and the concentrations of rotenone equivalent to the survival periods thus obtained were determined from the rotenone curve previously established. From the ratio of these two different concentrations, i.e., concentration of extract at which tested (parts rotenone per million) to concentration of rotenone corresponding to survival time (parts rotenone

per million), an average factor was obtained. The exposed deposits were then tested, and the concentrations of rotenone corresponding to these survival periods read from the rotenone curve. By multiplying these concentrations by the factor just obtained a concentration of extract (in terms of rotenone) equivalent to the survival time was obtained.[7] From the difference between these last concentrations and the concentration at which the exposed deposits were tested, the loss in toxicity was calculated as in previous tests.

TABLE 4. LOSS IN TOXICITY OF DERRIS EXTRACT DEPOSITS EXPOSED TO LIGHT

Insect tests

Exposure	Concentration at which tested (parts rotenone per million)	Survival time (min.)	Concentration of extract corresponding to survival time (pts. rotenone per million)	Loss in toxicity (per cent)
	2.5	111		
Not exposed	1.25	127		
(from stock)	0.625	175		
	0.312	293		
	0.156	1440(?)		
Sunlight—10 days	2.5	329	0.28	89
Sunlight—20 days	2.5	720 (?)	0.17	93

Fish tests

Exposure	Concentration at which tested (pts. rotenone per million)	Survival time (min.)	Concentration of rotenone corresponding to survival time (pts. rotenone per million)	Concentration* of extract corresponding to survival time (pts. rotenone per million)	Loss in toxicity (per cent)
Not exposed	0.088	112	0.125		
(from stock)	0.059	137	0.078		
Sunlight—10 days	0.297	167	0.057	0.042	86
Sunlight—20 days	0.314	179	0.050	0.036	88
	0.156	321	0.032	0.023	85
Arc-light—240 hrs.	0.730	390	0.029	0.021	97

*Calculated by using a factor for $\frac{\text{Concentration at which tested}}{\text{Concentration of rotenone corresponding to survival time}}$ of 0.73 which was obtained from the two check results.

The tests on the derris root were made and the results calculated in a manner similar to that used for the extract.

Both the derris root and the extract lost their toxicity quite rapidly (with the exception of the derris root deposit tested against goldfish) on exposure to light, and consequently it is unlikely that any material with protective properties is present in these products. The deposits kept in the dark underwent no change.

[7]In effect this amounts to shifting the rotenone curve to coincide with a total extract curve.

It is interesting to note that the solid extract tested by means of mosquito larvae gave survival periods of the same order as those previously obtained from equal amounts of rotenone. It would appear, therefore, that the extract, which was about one-fourth rotenone, had about the same toxicity to mosquito larvae as rotenone. This was not true of the toxicity to goldfish, the results obtained indicating that the extract was equivalent to about one-third of its weight of rotenone.

Similar results were obtained with the derris root, the tests against mosquito larvae indicating that the root contained about 8 per cent of material with toxicity equal to that of rotenone, whereas the root contained about this proportion of total extractives but only 1.4 per cent actual rotenone. The goldfish tests again indicated that the root was only slightly more toxic to these test animals than the amount of rotenone it contained.

A summary of the results in terms of percentage of toxicity lost by each deposit is given in Table 5. Each of these results represents the exposure of only one deposit. A graphic summary of the loss of toxicity of deposits exposed to sunlight and tested against mosquito larvae is given in Figure 40.

TABLE 5. LOSS IN TOXICITY OF VARIOUS MATERIALS EXPOSED TO LIGHT

	Loss (per cent) when exposed to sunlight				Loss (per cent) when exposed to arc-light			
	10 days		20 days		240 hours		480 hours	
Material	Insect tests	Fish tests	Insect tests	Fish tests	Insect tests	Fish tests	Insect tests	Fish tests
Rotenone	64	80	73	79	94	98	98	99
Dihydrorotenone	32	25	73	75	*	98	*	*
Rotenone hydrochloride	71	76	86	78	98	99	98	99
Rotenone-bentonite mixture	77	76	86	83	*	90		
Rotenone-lampblack mixture	37	49	29	51	67	87		
Derris root	75	41	91	73	*	92		
Derris extract	89	86	93	86		97		

*Loss practically complete.

DISCUSSION AND CONCLUSIONS

The present work has shown that the rather rapid decomposition of rotenone by direct sunlight, with the resulting decrease of its toxicity to insects, will limit its use as a stomach insecticide on fruit and foliage until some suitable means is found of retarding this loss of toxicity. The decomposition is not so rapid as to interfere with its use as a contact insecticide. The deposits on glass tested in the present experiments were much heavier than ordinary spray residues. If the particles next to the glass had not been more or less protected from light by those above, the loss of toxicity would undoubtedly have been greater. It is therefore

probable that a thin spray residue of rotenone exposed to sunlight for ten days would lose its toxicity completely.

The present tests have shown that a considerable degree of protection against sunlight is afforded by mixing rotenone with lampblack. It is

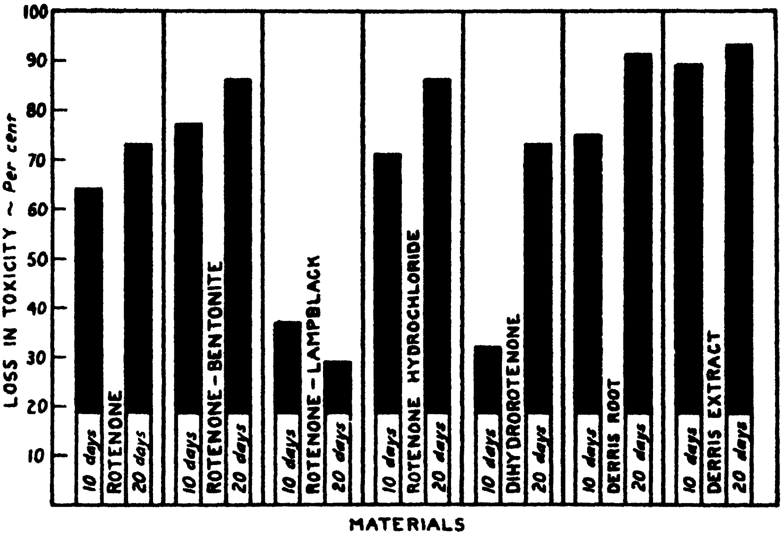


FIG. 40.—Loss in toxicity to culicine mosquito larvae of rotenone deposits, etc. exposed on glass plates to sunlight for 10 and 20 days.

doubtful, however, that a thin spray residue of rotenone-lampblack mixture would resist the action of light as much as the thicker deposits that were tested.

As an alternative to rotenone, dihydrorotenone may be worth testing on a small scale in the field. Its toxicity to insects approaches or equals that of rotenone, and it appears to be more resistant to decomposition by light.

Although this paper is not particularly concerned with the toxicity of unexposed derris extract, it should be pointed out here that the powdered extract used in the present tests against mosquito larvae was as toxic as rotenone, although it contained only about 25 per cent of that compound. These and other similar results may indicate the presence in acetone extracts of derris of one or more highly toxic substances that have not yet been isolated.

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THE EFFICIENCY OF TAR DISTILLATE SPRAYS IN CONTROLLING SAN JOSE SCALE IN 1932

By W. S. Hough, *Virginia Agricultural Experiment Station*

Abstract

Results of the second season's experiments with sprays containing coal tar distillates of English and American origin confirm the results of 1931. The higher concentrations may give control of San Jose scale (*Aspidiotus perniciosus*) comparable to that obtained with a standard petroleum oil spray of 3% oil. A combination of coal tar oil and petroleum oil against aphis eggs and scale in the dormant season is suggested.

This paper reports the results of the second season's experiments on the control of San Jose scale with sprays containing coal tar distillate. Apple trees severely infested with scale were sprayed on favorable days during the dormant season.

Three of the preparatory sprays contained tar oil of English origin. The other tar oils were of American origin. For convenience the four tar distillates which were emulsified for these tests are designated by number and data on distillation and specific gravity are given in Table 1. Tar distillate No. 1 was a redistilled oil. Tar distillate No. 4 is known to the trade as Carbosota and according to the producers is not necessarily redistilled but may be a blend to meet the distillation requirements. Distillates Nos. 2 and 3 are not redistilled. It should be stated that only the liquid part of the distillates are used in spraying, the solids having been removed by cooling and settling.

TABLE 1. SPECIFICATIONS OF COAL TAR DISTILLATES OF AMERICAN ORIGIN USED IN SPRAYING EXPERIMENTS OF 1932

	Specific gravity at 38° C	Distillation
Tar distillate No. 1 (a redistilled oil)	1.10	Up to 210° C. . ... 0 Up to 235° C . . .... 5% Up to 315° C .. ....30% Up to 355° C... .. ..65%
Tar distillate No. 2..	1.085	Up to 210° C less than 1% Up to 230° C..... ...99%
Tar distillate No. 3...		Up to 249° C less than 1% From 250° C up......99%
Tar distillate No. 4....	1.06	Up to 210° C.. ...... 1% Up to 235° C . ...10% Up to 355° C 65%

Most of the preparatory tar oil sprays or washes with which the writer is acquainted contain a certain amount of petroleum oil, usually from 16% to 20% by volume. Petroleum oil is added to aid in the emulsification of the tar oil which may constitute about 50% to 55% of the total volume. In a few American preparations the proportion of petroleum oil amounts to about one-third of the total volume and the tar oil from 42% to 47%.

Lubricating oil of 100 seconds viscosity (Saybolt) was used in emulsifying tar distillates Nos. 1 to 4 inclusive. The proportion of tar oil and petroleum oil when diluted is shown in Table 2. A convenient formula for making tar distillate emulsion is as follows:

Tar oil..	3 gallons
Petroleum oil....................................	1 gallon
Water and sodium caseinate........................	2 gallons

Sodium caseinate was prepared by dissolving about 7 ounces of powdered casein in one-half gallon of boiling water in which about 1½ ounces of sodium metasilicate had been dissolved. The total was then

diluted to two gallons. Petroleum oil was next added and the mixture pumped through a nozzle until emulsified. As the mixture was pumped back on itself, tar oil was gradually added and pumping continued until emulsification was completed. This results in a stock of 50% tar oil

Table 2. Results of Experiments on Control of San Jose Scale on Apple Trees, Winchester, Virginia, 1932

Date sprayed	Material used and amount in 100 gallons of spray mixture	No. of scales Examined	No. of scales Alive	Per cent control
1931	Smoot orchard			
Dec. 18	Tar distillate "Barko" 10 gallons	2,000	0	100
Dec. 18	Tar distillate "Barko" 6⅔ gallons	2,000	14	98
Dec. 18	"Metro Neutral Tar Wash" 10 gallons	2,000	85	91
Dec. 18	"Metro Neutral Tar Wash" 6⅔ gallons	2,000	147	85
Dec. 18	"Long Ashton Neutral Tar Wash" 10 gallons	2,000	78	92
Dec. 18	"Long Ashton Neutral Tar Wash" 6⅔ gallons	2,000	174	83
Dec. 18	Tar distillate No. 1			
	Tar oil 3%, petroleum oil 2%	2,000	37	96
	Tar oil 3%, petroleum oil 3%	2,000	4	99
Dec. 18	Petroleum oil emulsion (3% oil*)	2,000	48	97
Dec. 18	Petroleum oil emulsion (3% oil†)	2,000	0	100
1932				
Feb. 27	Tar distillate "Barko" 10 gallons	2,000	11	98
Feb. 27	"Metro Neutral Tar Wash" 10 gallons	2,000	44	95
Feb. 27	"Long Ashton Neutral Tar Wash" 10 gallons	2,000	49	95
Feb. 27	Tar distillate No. 1			
	Tar oil 3%, petroleum oil 2%	2,000	82	92
	Tar oil 3%, petroleum oil 3%	2,000	31	96
Feb. 27	Tar distillate No. 2			
	Tar oil 7%, petroleum oil 2.2%	2,000	7	99
	Tar oil 5%, petroleum oil 1.5%	2,000	25	97
Feb. 27	Tar distillate No. 3			
	Tar oil 7%, petroleum oil 2.3%	2,000	70	93
	Tar oil 5%, petroleum oil 1.6%	2,000	84	91
Feb. 27	Tar distillate No. 4			
	Tar oil 7%, petroleum oil 2.3%	2,000	77	92
	Tar oil 5%, petroleum oil 1.6%	2,000	166	83
Feb. 27	Petroleum oil emulsion (3% oil*)	2,000	37	96
	Check, not sprayed	2,000	1,022	(51.1%)
	Marker orchard			
Apr. 2	Tar distillate "Tarolene" 6 gallons	1,000	4	98
Apr. 5	Petroleum oil emulsion (3% oil‡)	1,000	0	100
	Check, not sprayed	1,000	255	(25.5%)

*Viscosity (Saybolt) 100 seconds.
†Viscosity (Saybolt) 225 seconds.
‡Viscosity (Saybolt) 150 seconds.

which pours readily. Variation in the proportion of tar oil and petroleum oil is possible. In the above formula if the water is decreased to one gallon and the petroleum oil increased to 2 gallons, the stock becomes a very thick paste which will not pour.

No evidence of serious injury to apple trees has appeared following the use of tar oils in the dormant season. A slight delay of bud development is sometimes observed. Several orchardists who used tar dis-

tillate sprays for control of aphids complained of the caustic action on the skin. This objection was largely overcome by greasing the exposed skin before attempting to apply the spray.

Examination of the scales began in late March in the Smoot orchard and was concluded May 9 in the Marker orchard. The results are given in Table 2 and indicate that the higher concentrations of tar oil sprays may compare favorably with a petroleum oil spray of 3% oil Similar results were obtained in the experiments of 1931[1].

Inasmuch as a standard 3% petroleum oil spray will usually give better than 95% control of San Jose scale, it follows that tar distillate emulsions should be equally effective in order to be of practical value where the control of this insect must be taken into consideration On the other hand, under Virginia orchard conditions of the past two seasons, experience with tar distillate sprays for the control of aphids in the egg stage indicates that not over 2¾% tar oil is sufficient to give 100% kill. The practical advantage of using more than 3% tar oil does not appear under our orchard conditions Where both aphids and San Jose scale are the principal pests to be controlled in the dormant season, a combination is suggested of sufficient tar oil to kill aphis eggs and sufficient petroleum oil for adequate control of the San Jose scale.

PRESIDENT FLINT. These are a class of sprays that are bound to be coming into use pretty generally. Our experience in Illinois has been just about the same as that reported here.

MR. BLAUVELT: I should like to ask how the tar distillates compare with a mixture of cresylic acid and oil emulsions.

MR. HOUGH: We got very good results with both cresylic acid and oil.

PRESIDENT FLINT: I should like to ask how much of a chance you are taking in the late applications of cresylic acid.

MR. HOUGH: We have been using it for three years and have not had any bad effects from using one-half per cent in the delayed dormant period. We try to finish spraying when the leaves are a quarter of an inch long. We have put it on later than that and have gotten some burning.

[1]Jour. Econ. Ent. Vol. 25, No. 3, pp. 613–617, June 1932.

EXPERIMENTS WITH TAR DISTILLATE SPRAYS AGAINST FRUIT APHIDS AND ASSOCIATED INSECTS

By F. Z. Hartzell, P. J. Parrott, and S. W. Harman, *Geneva, N. Y.*

ABSTRACT

Field trials of tar distillate sprays were conducted in a number of orchards in western New York during 1932 to determine their effects on the trees and efficiency in controlling rosy apple aphid, black cherry aphid, San Jose scale, oyster-shell scale, eye-spotted bud moth, apple red bug, and pear psylla. Four American and four European brands were used in the experiments. Concentration of tar washes in the applications on apples generally varied from 5 to 7½ per cent, altho mixtures containing 2 and 3 per cent were tried on a few trees. Except in the case of one plat that was sprayed very late in the fall, all applications on the apple were made in the spring not later than the gray-tip stage of the buds. On sweet cherry and pear, the mixtures contained 4 and 5 per cent of the emulsions respectively.

Control of the rosy apple aphid was secured in all trials when the concentrations of tar washes were not less than 5 per cent. Lower concentrations generally proved less effective. A fall application did not give as high control as spring treatments. In practically all instances, the control of rosy apple aphid by spring applications of tar washes (not less than 5 per cent) was similar to that effected by nicotine sulfate (1–800). A single experiment indicates that these materials may prove effective against the black cherry aphid. Tests with one brand indicate that in severe infestations, tar distillate sprays are not as effective as lubricating oil emulsions for the control of San Jose scale. Four brands, used at 5 and 7½ per cent, appear to be very effective on oyster-shell scale. Tar washes (7½ per cent) in the tests were but slightly inferior to nicotine sulfate (1-400) in lubricating oil against the eye-spotted bud moth, while lower concentrations of the washes produced moderate control. The results with apple red bug indicate that rather low efficiencies are to be expected from tar washes (7½ per cent) when used against this insect. One brand (5 per cent) proved destructive to the eggs of pear psylla. At the concentrations used none of the materials proved injurious to the buds or wood of apple, sweet cherry and pear during 1932.

The results with tar distillate sprays given in this paper were secured during 1932 and they supplement those of previous investigations which have been reported.[1] All the trials, except two which were made on young bearing trees, were conducted in mature orchards on the Station grounds, and in commercial plantings located in six counties of the western New York fruit belt. Applications were made with orchard sprayers maintaining pressures varying from 250 to 350 pounds, and equipped with spray-guns except in one orchard where rods carrying four cyclone nozzles were used. The methods of securing data are described under each species.

Tar Distillates.—The domestic brands tested were Barko, Koppers' Tar Wash, Tarolene, and Tarzol. The following foreign brands were also tested: Carbokrimp, Mortegg, Solignum Dormoil and Solignum

[1]Jour. Econ. Ent. 24. 297–302. 1931; *Ibid* 25: 607–613. 1932.

Long Ashton Wash. Barko was used most extensively in commercial orchards partly because of the large amount of material on hand, but especially for the reason that it had been tested during the two previous seasons. Most of the other brands had not been tried under New York conditions so caution in their use was necessary until the question of safety to trees could be determined.

INSECT CONTROL.—Data were secured as regards the effects of tar distillates on the control of the following insects: Rosy apple aphid (*Aneuraphis roseus* Baker), black cherry aphid (*Myzus cerasi* Fab.), San Jose scale (*Aspidiosus perniciosus* Comst.), oyster-shell scale (*Lepidosaphes ulmi* L.) eye-spotted bud moth (*Spilonota ocellana* Schiff.), apple red bug (*Lygidia mendax* Reut.), and pear psylla (*Psyllia pyricola* Foerst.).

Rosy apple aphid. The methods of securing data are first described. Counts of infested leaf clusters were made during early July on treated and check trees. During harvest time, in some of the plantings where the trees bore fruit, counts were made of the total number of injured and perfect apples on each tree used for such data.

Trials of tar washes for rosy aphid control were conducted in five orchards, in some of which other pests also received consideration. All spring applications were made by the time the buds were in the gray-tip stage. The largest number of tests were carried out in what is familiarly known as the Rome Beauty orchard on the Station grounds. There are 55 trees of this variety and 118 trees of other kinds of apples, many without duplicates. All of these were about 30 years of age Among the Rome Beauty experiments, one plat was sprayed in December, 1931, with Barko (5 per cent)[2]; one plat with the same mixture during the spring; and one plat with nicotine sulfate (1–800) in lime-sulfur (1–40) at the delayed dormant period. On the basis of cluster counts, the per cent efficiency was as follows: Barko (fall treatment) 98; Barko (spring treatment) 95; nicotine, 100. Fruit counts gave Barko (fall) 77; Barko (spring) 91; and nicotine, 90 per cent efficiency.

Spring applications of the following materials at 7 per cent concentration gave 100 per cent control based on cluster counts; Koppers, Solignum Long Ashton, Tarolene, and Tarzol. Owing to scarcity of bearing trees on which to make tests, these materials were used at this higher amount to test especially their effects on buds and wood. With the exception of the Solignum wash, these brands had not been tested previously by the writers. Trees treated with various brands (3 per cent)

[2]All percentages refer to the amount of concentrated emulsion used and not to the actual tar distillate content of the spray mixture.

either alone or with petroleum oil (3 per cent) gave ambiguous results. However, 2 per cent concentration of various brands gave efficiencies varying between 42 and 62 per cent based on cluster counts.

In an old Oswego county orchard certain plats were sprayed with Barko and Mortegg, each used at 6 per cent concentration. Another plat was given a delayed dormant application of nicotine sulfate (1–800) in lime-sulfur. The varieties were Greening, Baldwin and McIntosh, and the following efficiencies were found (based on leaf clusters): Barko 91, 89, and 79; Mortegg 92, 92, and 83; nicotine 89, 82 and 77 per cent for the several varieties in the order listed.

Plats in a Greening orchard (15 years) in Monroe county gave the following: Barko (5%), 99.7; Barko (6%) 99.9; and nicotine sulfate (1–800) 97.6 per cent efficiency based on cluster counts.

A ten-year Ontario county orchard of Rome Beauty and Greening trees was sprayed with three brands of tar washes at 5 per cent concentration. The efficiencies of the materials, based on cluster counts, on Rome Beauty and Greenings were: Barko, 84 and 80; Carbokrimp 95 and 86; Mortegg 91 and 90 per cent.

A thirty-year-old orchard in Wayne county consisting of three varieties was treated with Barko 5 and 7½ per cent and cluster counts were made. The efficiencies for the 5 and 7½ per cent concentrations were: Greening, 90 and 92; Baldwin 88 and 89; and Ben Davis 85 and 95 per cent respectively.

Black cherry aphid. Four Windsor cherry trees in a Wayne county orchard were sprayed with Barko (4 per cent) on April 21, 1932. At this time the buds were swollen to such an extent that the tips were green. Serious bud injury was expected, which accounts for the small number of trees treated. With the exception of four check trees, the remainder of the orchard was given an application of nicotine sulfate (1–800) in lime-sulfur when the young leaves were from ¾ to 1 inch in length. Counts of infested clusters showed the following efficiencies: Barko 99.6; nicotine 48.4 per cent.

San Jose scale. Tests of Barko (5 per cent) against this insect were made at Geneva in an orchard that was severely infested. At the same time a plat was treated with lubricating oil emulsion (3 per cent oil). The data, taken when the apples were picked, were based on the presence or absence of San Jose scale on the fruit. The percentage of clean fruit on each plat was as follows: Barko 59; lubricating oil 98; check 7. These represent control efficiencies of 56 and 98 per cent respectively. In addition, counts of scale on the fruit were made, the averages per 1000 apples being: Barko, 2786; lubricating oil, 80; check, 62,231. These

counts indicate the following toxic efficiencies of the materials: Barko, 95.5; lubricating oil, 99.9 per cent.

It will be recalled that the writers reported good control of San Jose scale by means of tar washes during 1931[3]. These observations were made on moderately infested trees, which perhaps accounts for the differences in results during the two seasons.

Oyster-shell scale An extensive series of tests of tar washes at 5 and 7½ per cent concentrations and also of lime-sulfur (1-8) were conducted in an apple orchard in Cayuga county. The brands used were Barko, Carbokrimp, Mortegg and Tarolene. The oldest trees were about 60 years old and about 30 feet tall, while numerous trees that replaced those that had died varied from 10 to 20 years of age. Most of the trees were very seriously infested with oyster-shell scale. On treated and check trees, counts were made of young scale that settled on wood of the past three years' growth and of the number of overwintering scale present on the same area of bark. Counts were made in the orchard July 25 and Mortegg (5 per cent) indicated an efficiency of 99.2 per cent. Owing to the large number of insects counted (3033 in this instance) under a lens to determine the abundance on a treated tree and its check, it was found impractical to attempt to secure all the data by means of counts made in the orchard, especially since changing conditions might introduce error. Therefore, a number of twigs were taken from individual trees scattered thru the planting, care being taken to secure samples from a number of trees in every plat. All these samples were carefully tagged and preserved in formalin The counts have not been completed.

On July 25 each plat was carefully examined and it was observed that all the tar washes either at 5 or 7½ per cent concentration had given much the same degree of control that was found on the tree sprayed with Mortegg (5 per cent). On the other hand, lime-sulfur (1-8) had not given as high degree of control as did the tar washes. In order to make further observations the orchard was visited on December 6. The wood on the check trees was found to be seriously injured by the oyster-shell scale, while all the sprayed trees had healthy wood and a light infestation of scale that had hatched during the summer. The trees sprayed with lime-sulfur, however, had a heavier infestation than those treated with tar washes.

Eye-spotted bud moth. Data on this pest were secured by counting the webbed leaf clusters during June. Tests were made in three orchards. In the Ontario county orchard previously mentioned, three brands of tar

[3]Jour. Econ. Ent. 25:607-613. 1932.

washes at 5 per cent concentration were applied. The efficiency of control on Rome Beauty and Greening trees were as follows: Barko 74 and 65; Carbokrimp 77 and 70; Mortegg, 77 and 69 per cent.

In the Wayne county orchard referred to under rosy aphid, Barko was used at 5 and 7½ per cent dilutions respectively. The efficiencies on the three varieties on bud moth were: Greening, 73 and 83; Baldwin, 61 and 69; Ben Davis, 77 and 78 per cent. A block of Baldwins sprayed in the delayed dormant with nicotine sulfate (1–800) in lime-sulfur gave an efficiency of 67 per cent.

In the Monroe county orchard previously mentioned the following efficiencies against bud moth were secured: Barko (5 per cent), 47; Barko (6 per cent) 75; lubricating oil (6 per cent) and nicotine sulfate (1–400) 86 per cent.

Apple red bug. Tests of Barko and Carbokrimp at 6 per cent concentration in an orchard in Niagara county gave practically no control of the apple red bug. The trees were of the Greening variety between 15 and 20 years of age. In experiments aimed at the control of this insect the data were taken by counting all injured and perfect apples on the treated and check trees at harvest time.

A block of McIntosh trees, 25 years of age, in Wayne county was sprayed with Barko (7½ per cent). If the comparison is made on the total amount of fruit from treated and check trees, the efficiency was 49 per cent. However, if the sprayed trees in each row from west to east be compared with the corresponding check tree, there is a rather uniform increase in efficiency from 0 to 66 per cent with an average of 33 per cent. In view of previous results of tar washes against this insect it is possible that the indicated control is too high, owing perhaps to irregular infestation so characteristic of apple red bug.

Pear psylla. Since pears have usually proven more susceptible than apples to spray injury with other materials, experiments with tar distillates have been made only on trees that owners intended to remove later. Thus, tests have been restricted until the question of tree and bud injury has been decided. Barko (5 per cent) was used on six trees in Wayne county during 1932. No bud or tree injury occurred and every pear psylla egg hit by the spray was killed. Moreover, the material seemed to prevent later oviposition resembling, in this respect, lubricating oil treatments.

Effect on trees. Since in 1931 tar washes at concentrations of 8 per cent or more were found to cause very serious bud injury on some varieties of apples, none of the brands were used at concentrations of more than 7½ per cent during 1932. No injury occurred with any of the

brands used during this latter year, provided treatment was made not later than the gray-tip stage. Greening and Rome Beauty trees were given fall application (5 per cent) and in neither case did injury occur. Moreover, a block of Rome Beauty trees in a Station orchard have been sprayed with tar distillates (5 per cent) for three successive years, and to date no deleterious effects have appeared. There is usually considerable retardation in bud development on trees sprayed in the spring, but notably less on fall treated trees. In neither case has this retarded development proved objectionable. Mixtures of tar washes (3 per cent) and lubricating oil (3 per cent) did not cause injury to buds nor wood in 1932 It should be recalled that higher concentrations of this combination proved disastrous to apple buds in 1931 Even the wood was killed where excessive concentrations were used

Windsor sweet cherry buds were not injured by Barko (4 per cent) altho the spray was applied when the tips were green However, the observations are too meager to decide whether or not such late applications are safe

Neither swollen Bartlett pear buds nor wood were harmed by Barko (5 per cent) but the question of safeness of tar distillates on pears has not been fully decided.

CONCLUSIONS —At not less than 5 per cent concentration, spring applications of the several brands of tar washes gave fairly uniform results and show efficiencies similar to nicotine sulfate (1–800) on the rosy apple aphid in the same plantings At concentrations of 3 per cent, the tar distillates either alone or combined with lubricating oil, gave variable results against this insect. Lower concentrations generally proved less effective Fall applications of Barko (5 per cent) seemed to be somewhat inferior to spring treatments with the same mixture, judged by percentage of injured fruit. Three seasons' results indicate that tar distillate sprays offer a means of control of the rosy apple aphid that supplements nicotine.

One year's test indicates that tar washes may prove very effective for preventing destructiveness by the black cherry aphid.

With San Jose scale, the data suggest that for an infestation such as occurred in the orchard when the tests were made (1) unless a material shows a killing efficiency of about 99 per cent, a relatively clean crop of fruit is not to be expected during the first season's treatment; (2) statements of the proportion of San Jose killed are apt to be misleading unless checked by the proportion of clean fruit harvested; (3) lubricating oil sprays seem to afford a more satisfactory control than do some of the

tar washes at 5 per cent dilution; (4) Barko (5 per cent) apparently has sufficient toxicity on this insect to reduce the pest considerably.

The four brands tested on oyster-shell scale at 5 and 7½ per cent concentrations appear to be very effective and to surpass somewhat lime-sulfur 1–8. These results corroborate the findings in 1931 when a treatment with Barko (7½ per cent) greatly reduced the amount of this insect on an experimental tree.

Against the eye-spotted bud moth, tar washes at 7½ per cent concentrations proved slightly inferior to a mixture of lubricating oil (6 per cent) and nicotine sulfate (1-400). At concentrations of 5 and 6 per cent, two washes gave only moderate control of this insect Little difference in control was found with the several brands tested.

In general, tar distillates do not offer as satisfactory control of apple red bug as does nicotine sulfate (1 800) in the calyx application

Tar washes seem to offer another material that can be used as an early spray for pear psylla.

When concentrations of not more than 7½ per cent were used, none of the tar washes caused injury to the trees or buds of apple in 1932 Sweet cherry buds that were showing green tips were not injured by Barko (4 per cent) However, since only one test was made little can be said about the possibility of damage with applications made at such an advanced stage. It would probably be safer to spray earlier even if a slightly stronger mixture may be needed to secure control. No injury occurred to swollen pear buds or the wood, so it appears that the way has been cleared for more extensive tests against the pear psylla with tar distillate sprays.

TESTS WITH TAR DISTILLATE SPRAYS FOR FOLIAGE APPLICATIONS

By F. Z. Hartzell, *New York State Agricultural Experiment Station, Geneva, N. Y.*

Abstract

Tar distillates were tested as foliage sprays on numerous varieties of apples in an effort to determine their value for codling moth and apple aphid control. Four brands of tar washes were used with standard fungicides; viz., lime-sulfur (1–40), bordeaux mixture (4–8–100), and dry-mix sulfur and lime. In the tests on young McIntosh trees comparisons were made with untreated trees and those sprayed with each fungicide mixed with arsenate of lead. In trials on many varieties of bearing trees, comparisons were made between those of the same variety sprayed with the same fungicide in which arsenate of lead replaced tar distillates. These latter were found apparently compatible with the three fungicides. The results against apple aphid were irregular and contradictory so no marked value of these materials was

noted. Based on "wormy" apples, arsenate of lead proved superior in every one of the sixteen comparisons, while the same material gave better control in fifteen of the sixteen pairs of tests when the total codling moth injuries were considered. The problem of spray residue was not eliminated. Leaf injury, russeting and pitting of the fruit on a number of varieties leads to the conclusion that the causes of these injuries must be determined and eliminated before much progress can be made in experimentation with tar distillate sprays for control of the codling moth.

During recent years numerous tests of various chemicals and mixtures have been made by many entomologists in an effort to find materials that can replace arsenicals, especially for those applications that contribute most heavily to the formation of excessive residues. Accordingly, it seemed desirable to determine the value of tar distillates as foliage sprays on apples for the control of codling moth and other insects that might be sufficiently abundant during the summer, especially after the fruit has reached one-third or one-half its full size. The series of field tests herein described were conducted during 1932 at Geneva, N. Y., to gather information on this problem. Owing to the vagaries of apple pests only two species were present in sufficient number to secure reliable data on control; namely, the codling moth (*Carpocapsa pomonella*) and the apple aphid (*Aphis pomi*). The studies had the following objectives: (1) Control of codling moth and other apple insects; (2) miscibility and compatibility with standard fungicides; (3) effects on foliage and fruit when the tar washes are used alone and with fungicides; (4) amount and character of residue on ripe fruit; and (5) cost.

MATERIALS.--Unfortunately for the experimenter, tar distillate emulsions[1] have not been standardized as regards the specifications and amount of tar oils, presence or absence of petroleum oils, and kind or amount of emulsifier. In a complete investigation, especially when used with and without different fungicides and on different varieties of apples, it would be necessary to use a very extensive series of tests in which the various factors would be varied one at a time in each trial while holding the others constant if the effect of each factor were to be accurately determined. A little calculation will show that using only three different fungicides and the leading commercial varieties of apples and also making moderate changes in the kinds and amounts of ingredients in the various mixtures would result in an extremely large number of tests. In fact there would be required, at least for the writer, an impractical number of trials during a single season as regards time, expense, and available bearing trees.

[1]Stock mixtures of tar distillates that emulsify with water are marketed as emulsions and miscible oils. For brevity the term "emulsion" will be used for both types.

For preliminary tests it seemed preferable to select several representative brands of tar distillates and use them on a number of varieties of apples, combining each brand with several standard fungicides, at the same time using some of the emulsions without fungicides. Two foreign brands (Carbokrimp and Mortegg) and a domestic brand (Koppers) were selected because these were believed to be free from petroleum oils and were emulsified with different materials. One American brand (Barko) was selected because it contains a small amount of petroleum oil in addition to the tar distillates. Each of the brands were combined with three fungicides; namely, lime-sulfur, 1–40; bordeaux mixture (4–8–100); and dry-mix sulfur and lime, 25 pounds in 100 gallons of spray mixture. At the same time, all the brands of tar washes mentioned were used alone in one series of trials, but in the second series only one brand was tested without fungicides.

Experimental.— Preliminary trials during the preblossom period indicated that on some varieties, at least, tar washes at a dilution of one gallon of the emulsion in 99 gallons of water would cause considerable foliage injury; so it was decided to use three-fourths gallon in 100 gallons of mixture either alone or with fungicides for further tests on foliage. The first series of trials was made June 17, 1932, on two-year-old McIntosh apple trees in the insectary garden. All brands were found to mix easily with each of the fungicides Four trees were sprayed with each mixture. Controls consisted of trees that were not treated and those sprayed with the several fungicides mixed with arsenate of lead. The day was clear with a maximum temperature of 85° Fahr. and a very light southeast breeze (almost a calm). The trees were examined daily. By June 29 some trees revealed slight foliage injury when certain brands were added to lime-sulfur, while those treated with tar washes in either bordeaux mixture or dry mix showed very slight injury or no change from the condition of the control trees. When used without a fungicide all brands showed very slight injury to the foliage. Thus it appeared that the tar washes are compatible with these three fungicides. In some instances the addition of the latter actually decreased the leaf scorching when compared with the same brands used without a fungicide.

Since these trials on small trees indicated, by June 22, that tar washes (three-fourths per cent of the emulsion) could be used with comparative safety on apple foliage, and because this was the period when the first cover sprays were being applied, the tests were continued on bearing trees. Station Orchard No. 12, commonly known as the Rome Beauty Orchard, has in addition to this variety a large number of filler trees

about thirty years of age consisting of numerous varieties, many without duplicates and some not of commercial importance. Fortunately, some of the kinds have duplicate trees, and a few commercial varieties have from three to five replicates. In such cases one tree was sprayed with a tar wash mixed with a fungicide and a duplicate was treated with the fungicide and arsenate of lead as a check. Three cover applications were made on all trees, the last being applied July 18. All trees had been sprayed previously with lime-sulfur and arsenate of lead according to the regular schedule. Since there were twelve combinations of materials containing tar distillates and fungicides, also because the number of duplicate and replicate trees was small, only one tree was treated with tar distillate without a fungicide. This tree, a large Rhode Island Greening, was sprayed during the entire foliage spray season with Carbokrimp. The delayed dormant application was to determine the effect of the material (2 per cent of the emulsion) on young rosy apple aphids (*Anuraphis roseus*), while the later sprays (1 per cent of emulsion during the preblossom stage and ¾ per cent for later treatments) were for the purpose of studying the effect of the material on other apple insects, on fungous diseases, and on the general health of the tree. Forty-five trees consisting of nineteen varieties were used in these tests, constituting the second series.

RESULTS.– All the brands of tar washes previously mentioned were miscible and appear to be compatible with the three standard fungicides—lime-sulfur, dry-mix sulfur and lime, and bordeaux mixture. Late scab infection was very light in this orchard during 1932, for which reason the effect of tar distillates on the fungicidal properties of the mixtures could not be measured It will be recalled that one Rhode Island Greening tree was sprayed from the delayed dormant period up to and including the third cover spray with Carbokrimp, yet the amount of apple scab was but slightly higher than on a near-by Rhode Island Greening which received lime-sulfur 1–40 and arsenate of lead in the delayed dormant application and was sprayed with bordeaux mixture (4–8–100) and arsenate of lead thru the third cover spray. Since unsprayed trees of all varieties had a moderate amount of fruit infected with scab there is some indication that tar washes have good fungicidal action.

In the tests on bearing trees, foliage injury varying from slight to very slight occurred on some varieties. There was no correlation between the amount of injury or absence of the same and the kind of fungicide or the brand of tar wash. However, the tree sprayed with tar distillate alone showed more foliage injury than the tree treated with the same

brand mixed with a fungicide. These observations corroborated the results secured on the young McIntosh trees.

Russeting of the fruit varied from nothing on some varieties to severe on others. The degrees that this effect occurred are as follows: severe, British Columbia, Rhode Island Greening, and Westchester; moderate, Deacon Jones, Hubbardston, Kinnard, Sierra Beauty, Sir John Thornycroft, and Wagener; slight, Collins, Lady, Peerless, and Winter Banana; none, Adersleber Calville, Baldwin, Becker, Early Goodman, Giant Jeniton, and Summer Banana. In addition to russeting, four varieties sprayed with tar distillates developed a dark pitting of the skin, especially about the lenticels. This injury was noticeable at picking time and appears to have been accentuated during storage. The varieties showing this effect were Sierra Beauty, Wagener, Westchester, and Winter Banana. Three different brands of tar wash and three fungicides were involved in this defect. It appears, therefore, that foliage injury, russeting, and pitting are not related to the type of emulsifier, nor to specific differences in the several brands, nor to the kind of fungicide. Apparently these defects are associated with some characteristic or group of characters common to certain varieties. It is to be noted that the presence or absençe of petroleum oils apparently is not a factor in the cause of any of these undesirable conditions.

The flavor of the fruit did not seem to be affected in any variety. In this connection it is worthy of note that apples stored where they are exposed to the fumes of tar distillates have the flavor seriously affected by a strong taste of creosote. Baking, however, removes this flavor; but such fruit was not tested in pies.

Ripe fruit in a number of instances, especially with early varieties, had a considerable quantity of a black residue present which was not as easily removed by wiping as are arsenate of lead and fungicidal residues.

During the summer a marked infestation of the apple aphid appeared in this orchard. Counts of infested terminals show that while many of the trees receiving foliage sprays containing tar distillates appeared to give important reductions in the number of apple aphid over trees of the same variety sprayed with arsenate of lead and the same fungicide, in numerous other cases the differences were slight and in three instances the conditions were actually reversed. Moreover, the Greening tree that received a tar distillate spray thruout the spraying season after foliage was present showed practically the same number of infested terminals as did a near-by Greening tree that was treated with bordeaux mixture and arsenate of lead. These results indicate that foliage treatments with tar distillates are not dependable for the control of this insect.

Comparing trees of the same variety and on which the same fungicide was used, on the basis of "wormy" fruit, in no instance was a tar distillate spray as efficient against codling moth as arsenate of lead; nor did one brand of tar distillate used alone control the pest as well as did arsenate of lead and lime sulfur. Sixteen trees treated with tar washes in fungicides gave from 13 to 904 per cent (average 174 per cent) more "wormy" apples than did corresponding trees treated with arsenate of lead in the same fungicide. On the basis of total codling moth injury, fifteen trees treated with tar distillates had more injury from codling moth than the companion trees sprayed with arsenate of lead, while one pair of trees showed the contrary. The average gain for arsenate of lead was 88 per cent (range 3 to 389 per cent except the case where one tree showed a loss of 31 per cent). The data indicate that on the average the fungicides decreased the efficiency of codling moth control. Bordeaux mixture appears to have caused the most marked decrease, while lime-sulfur occupies a mid position and dry-mix seems to have had the least effect. There was a wide variation in codling moth control when the same brand was used on different varieties, so that altho some brands appear to have given better results than others, this point was not established and can be proved only by testing all the brands on the same varieties of apples.

At present prices the cost of 100 gallons of spray mixture, when the tar distillate emulsions are used at the rate of ¾ gallon in 100 gallons of mixture, varies from 26 to 38 cents. Arsenate of lead at the rate of 2½ pounds per 100 gallons, on the same basis, costs from 30 to 40 cents, so the difference in cost of materials is slight.

CONCLUSIONS.—The fact that tar washes apparently are compatible with fungicides may prove of value in orchard practice where it is desired to use these two remedial measures in dormant applications.

The field trials seem to indicate that before much progress can be made in experiments aimed at the control of codling moth and other orchard insects by use of foliage applications, the cause of leaf injury, russeting and pitting must be determined and eliminated.

With early varieties, residue from tar washes might be an important problem, not so much on account of any effect on the health of the consumer as that the fruit is made unsightly.

The effects of tar distillates on the apple aphid were so variable that it is impossible to state whether or not the insect might be practically controlled by the use of these materials in cover sprays at the dilution used. It might be possible that more careful timing of the application would result in higher and more constant efficiency against this insect. Even if

this result were possible, the practical value of the treatment would be influenced by the possibility of injury to the fruit.

Of sixteen comparisons on codling moth control, on the basis of percentage of "wormy" apples, arsenate of lead proved superior to tar washes in every case. Such a result would occur by chance only once in 65,000 times. On the basis of total codling moth injuries, arsenate of lead proved superior to tar distillates in fifteen of the sixteen comparisons, and in one instance the reverse was true. The odds of these results being due to chance are over 4,000 to 1. Note carefully, however, that neither of these odds prove that arsenate of lead is superior to tar washes in the control of this insect. All that they show is that in *this particular experiment* arsenate of lead apparently gave the highest control. Further tests may show that by more careful timing of the applications, with better mixtures, greater concentration or more frequent treatment, tar washes may prove to be of equal value or even more efficacious than arsenate of lead. On the other hand, unless fruit and foliage injury can be eliminated to such an extent that more treatments can be made, greater concentrations used, or more careful timing can be effected, it is difficult to see how tar washes can be used as foliage treatments in commercial orchards under New York conditions, at least with many varieties of apples.

THE RELATIVE TOXICITY OF TRISODIUM ARSENITE AND ARSENIOUS ACID TO THE HOUSE FLY, *MUSCA DOMESTICA* L.[1]

By Allen M. Pearson and Charles H. Richardson, *Iowa State College, Ames, Iowa*

Abstract

Solutions of arsenious acid and trisodium arsenite of various pH values were fed quantitatively to newly-emerged adult house flies. The solutions contained 15 grams of sucrose per 100 cc. Under these conditions, the toxicity of arsenious acid (pH 6.58 to 6.96) was indistinct from that of trisodium arsenite (pH 11.3 to 11.4), possibly the result of buffer action within the digestive tract. The M. L. D. for the two forms of trivalent arsenic was 0.14 mg. arsenic per gram of body weight. This is comparatively a large M. L. D. for an insect. Arsenious acid solutions were not repellent at any arsenic or hydrogen-ion concentration used; trisodium arsenite solutions of equivalent As concentration were not repellent at pH 11.3 and 11.4, but were distinctly repellent at higher pH values. In practice, no more alkali should be added to a house fly bait than is necessary to hold the trivalent arsenic in solution.

[1]Contribution from the Department of Zoology and Entomology.

Arsenious oxide dissolves in water to form the highly toxic arsenious acid which reacts with alkali hydroxides to produce toxic soluble arsenites. Arsenious acid is a weak, highly undissociated compound whereas its sodium salts, in aqueous solution, are highly ionized. A solution of arsenious acid contains, therefore, trivalent arsenic largely in molecular form whereas, in solutions of the sodium salt, the arsenic exists mainly as arsenite ions.

The investigation herein reported had three major objectives: First, to determine the relative toxicity, when administered by mouth to an insect, of trivalent arsenic in a highly molecular and in a highly dissociated form; secondly, to obtain quantitative data on the toxicity of trivalent arsenic to the adult house fly, *Musca domestica* L.; and thirdly, to compare the repellence of trivalent arsenic in nutrient solutions of varying hydrogen ion concentration to adults of the same insect. It was felt that the outcome of such an investigation would contribute toward the practical use of poison baits for this and possibly other insects.

MATERIALS.--The larvae of the flies were reared in a food mixture, similar to the one described by H. H. Richardson (11), at temperatures between 29° and 33° C. In order to avoid possible variation due to ingested food, only unfed adults, 6 to 8 hours after emergence, were used. Flies of this age will readily ingest dilute sugar solutions. The unfed flies weighed from 5 to 21 milligrams, but to obtain a population more homogeneous in size only those which weighed from 12.5 to 20 milligrams were accepted as experimental material.

Arsenious oxide C. P. was purified according to the method of Anderson and Story (1) which converts the compound to the octahedral crystalline form. It was dissolved in distilled water to produce the arsenious acid solutions. Trisodium arsenite solutions were prepared from stoichiometric quantities of the oxide and of a standard sodium hydroxide solution which was practically free from carbonates and silicates. Under ordinary conditions, only monosodium arsenite probably exists in solution but in order to obtain solutions of high pH value, in which dissociation approaches a maximum, the quantity of sodium hydroxide, above stated, was used. The arsenic content as As_2O_3 was determined by the standard iodine titration method. Cane sugar (sucrose) was added to all the arsenical solutions at the rate of 15 grams per 100 cc.

METHODS.—A single fly was weighed in a tared weighing bottle, allowed to imbibe a drop of the solution, and immediately weighed again. The quantity of food ingested was determined by difference, all

weighings being made to the fourth decimal place. From these data, the ingested dosage, in milligrams per gram of body weight was calculated. The arsenical solution was offered to the insect on a glass plate beneath an inverted weighing bottle. The fly usually located and ingested the drop in less than two minutes. If allowed to feed freely, many of the flies will consume more than their weight of solution in less than one minute. Since engorgement was nearly always closely followed by regurgitation, it was found necessary to control the quantity of solution imbibed. By the use of a simple micropipette the volume of the drop offered was kept approximately within 0.0025 cc. to 0.0030 cc. This procedure practically eliminated loss of food by regurgitation. In the very few cases of regurgitation observed, the fly generally died in a few hours, suggesting that the arsenic had induced expulsion of the material after the lethal action had begun.

The error resulting from the adherence of the arsenical liquid to the legs of the fly is well within the experimental error of the method as evidenced by the use of stained solutions. Flies which fed upon these solutions left no visible marks on a clean glass plate when they walked upon it.

After each fly was fed and weighed it was placed in an individual cage at room temperature, and observed at intervals for 144 hours. The food consisted of fresh milk which was fed twice daily. A corresponding number of control insects which were initially fed an equivalent cane sugar solution (without the arsenical compound), were caged and fed in the same manner. Of the 85 control flies used in the trisodium arsenite tests, 2 died in 8 hours, 4 in 60 to 113 hours, mean 82 hours, and 79 survived. The 109 controls of the arsenious acid series were less viable; 2 died in 20 to 24 hours, 19 in 44 to 140 hours, mean 98 hours, and 88 survived.

Results of the Toxicity Experiments.—The data (see Table 1) do not show a marked difference in the toxicity of the two compounds when administered to this insect according to the described methods. The data are statistically treated by first placing them in lethal, intermediate and sub-lethal zones (4) which in turn are divided into appropriate time-survival groups (8). The median lethal dose (M. L. D.) is calculated statistically from the last two time-survival groups in the intermediate zone.

The M. L. D. of 0.17 milligram of As_2O_3 per gram of body weight for trisodium arsenite is calculated from the means 0.187 and 0.159. By statistical comparison (5) these figures are distinct and therefore 0.17 is only an approximation to the M. L. D., but it is the best available

TABLE 1. TOXICITY OF TRISODIUM ARSENITE AND ARSENIOUS ACID TO THE HOUSE FLY

Material	Zone	No. flies	Body weight of flies in mg.			Survival time in hours			Dosage in mg. As_2O_3 g. body weight			Median lethal dose in mg. As_2O_3/g. body weight
			Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	
	Lethal	4	13.3	13.5	13.6	5	6	8	.258	.273	.293	
		15	13.1	15.1	18.0	1	6	15	.139	.216	.243	
Trisodium arsenite	Intermediate	4	13.1	14.6	17.9	16	20	50	.128	.205	.233	
		12	13.6	15.8	18.6	51	92	144	.108	.187	.233	0.17 (0.18)
		37	12.5	15.5	19.8		Recovered		.110	.159	.250	
	Sub-lethal	13	14.3	16.9	19.2		Recovered		.060	.090	.103	
	Lethal	7	13.0	14.4	15.0	1	11	36	.307	.325	.349	
		21	13.0	14.2	17.0	1	10	15	.109	.220	.280	
Arsenious acid....	Intermediate	16	13.0	15.4	19.3	16	26	50	.152	.228	.298	
		7	12.7	14.0	17.0	51	103	144	.181	.197	.217	0.19 (0.18)
		52	13.0	15.3	20.0		Recovered		.111	.186	.302	
	Sub-lethal	6	15.0	16.5	18.6		Recovered		.085	.095	.105	

estimate from this treatment of the data. The figure 0.187 is, however, statistically similar to the means, 0.197 and 0.186 of the intermediate zone of arsenious acid. The latter two means are also indistinct ($p = 0.5$). No explanation is offered for the low value of the mean 0.159 in the intermediate zone of trisodium arsenite. In the same manner, the mean survival times, 92 hours and 103 hours, are found to be indistinct ($p = 0.4$).

The toxicity data have also been analyzed by the method of Trevan (13), in which the percentage of mortality is plotted against the dosage. The M. L. Ds by this treatment are 0.18 and 0.21 mg. As_2O_3/gram for trisodium arsenite and arsenious acid respectively; by the method of Campbell and Filmer (4) they are 0.19 and 0.20 respectively. Regardless of the method of treatment, no marked difference was found between the M. L. Ds of the two compounds. The average of the M. L. Ds in Table 1, 0.18, is therefore accepted as the M. L. D. of these two arsenical compounds under the given conditions for the house fly.

Results of the Repellent Experiments.—The repellence was determined by the ingestion or rejection of the drop of solution offered to the fly. The flies employed for this purpose were largely those which were used in the toxicity experiments. From 12 to 15 additional flies, of similar age and weight, were used with each of the 5 trisodium arsenite concentrations greater than 0.132 gram As_2O_3 per 100 cc.

The behavior of the fly in contact with the food was, in general, consistent and characteristic. Upon approaching the drop of liquid, the fly touched it first with the proboscis and soon afterwards with the fore tarsi. If the liquid was strongly repellent, the fly backed away immediately and turned around. If, however, the repellent action was weak, the fly with its proboscis touching the drop, often hesitated before moving away, and sometimes ingested a small portion of the liquid. With subrepellent concentrations, ingestion of the liquid offered was immediate and complete.

A summary of the repellent data is given in Table 2. Arsenious acid solutions were readily ingested at all concentrations of arsenic (As_2O_3) offered regardless of the hydrogen ion concentration. Trisodium arsenite solutions, of equal As_2O_3 content, showed a definite repellent effect at concentrations greater than 0.148 gram per 100 cc., the hydrogen ion concentration in this region falling between pH 11.4 and 11.5.

It appears that repellent action is positively correlated with the pH of the solutions within the range of the arsenic and the hydrogen ion concentrations employed. The pH of the solutions, as administered, was

determined with the glass electrode.[2] The electrode was carefully checked against phosphate buffers of the same pH range as the experimental solutions.

TABLE 2. REPELLENCE OF TRISODIUM ARSENITE AND ARSENIOUS ACID TO THE HOUSE FLY

Grams As_2O_3 per 100 cc. of solution*	Trisodium arsenite		Arsenious acid	
	pH	Repellence	pH	Repellence
0.066	11.3	None	6.96	None
0.085	—	None	—	None
0.099	—	None	—	None
0.115	11.4	None	6.86	None
0.132	—	Slight	—	None
0.148	—	Slowly ingested	—	None
0.165	—	30%	—	None
0.181	11.5	70%	6.78	None
0.198	—	100%	—	None
0.330	11.8	100%	6.58	None

*All solutions contained 15 grams of cane sugar per 100 cc.

DISCUSSION.—When this investigation was planned, it was thought that results might be obtained similar to those previously reported (10) for the toxic action of molecular and ionic solutions of nicotine on mosquito larvae. It was realized, however, that the experimental conditions were different; that in the digestive tract of the adult house fly the presence of an acidic or an alkaline solution of trivalent arsenic might induce the secretion of substances which would shift the hydrogen ion concentration of the contents of the tract toward the normal value. If such a buffer action occurred, the toxicity of the nearly neutral arsenious acid solution and of the highly alkaline trisodium arsenite solution might become approximately equal. The results clearly show that when these two forms of arsenic in sucrose solution are ingested, they are of approximately equal toxicity. Unfortunately, neither the hydrogen ion concentration nor the buffer value of the digestive tract of the adult house fly appears to be available. The recent work of Swingle (12) on the digestive tract of the larvae of the Japanese beetle (*Popillia japonica* Newm.) indicates, however, that a strong buffer action toward acids exists in this insect; it is not illogical to assume an equally great buffer action in the alimentary tract of the omnivorous adult house fly.

Very recently, the work of Hoskins (6) on the toxicity to mosquito pupae of solutions of sodium arsenite of various hydrogen ion concentration has appeared. The results of this investigation show that the toxic action of acid solutions (pH 5) is about 4.5 times as rapid as that of basic solutions (pH 11). As mosquito pupae do not have a mouth

[2]The authors are indebted to Professor L. D. Goodhue, Department of Chemistry, Iowa State College, for these determinations.

opening, penetration of the arsenic through the external body tissues is the controlling factor in the toxicity of the solutions. Hoskins also noted that acid and basic solutions of trivalent arsenic show a much smaller difference in toxicity to mosquito larvae than to the pupae, and states that this might result from the buffer effect of the intestinal contents of the larvae

The available information encourages one to speculate upon the buffer action of the digestive tract of insects toward toxic substances which are most effective at certain pH values If, for example, the substance were most toxic at a low pH value, the buffer effect might be exerted in the direction of a higher pH at which toxicity would be reduced

The results given in Table 1 indicate that the M L D of the two forms of trivalent arsenic is 0 18 mg As_2O_3/gram or 0 14 mg As^{+++}/gram. Calculated in terms of arsenic, this is the largest M L D. for an insect with which we are familiar. It is more than double the M L D as arsenic for *Melanoplus femur-rubrum* (DeG.) (9) and from about 7 to 10 times that given for several lepidopterous caterpillars (2, 3) The M. L. D. for the house fly, it will be recalled, was obtained with adult insects less than a day after emergence. Whether flies of this age are more or less susceptible to arsenic than older flies was not learned from this investigation.

Within a 5-fold range of arsenic concentration, nearly neutral solutions of arsenious acid (pH 6.58 to 6.96) are not repellent to the adult house fly. On the alkaline side, solutions of equivalent arsenic concentration become repellent at pH values greater than 11.4. It is apparent, therefore, that the house fly will readily imbibe solutions of high pH value even when they contain a very toxic concentration of arsenic. The investigations of Lloyd (7) may be interpreted as indicating that the house fly is even more sensitive to acid (formic acid) than to alakaline solutions.

Considered from a practical viewpoint, the results of the experiments indicate that a relatively large quantity of sodium arsenite is required in a house fly bait. However, the frequent recommendation of 1 gram per 100 cc. of solution appears to be adequate. The results further show that highly alkaline bait solutions should be avoided and that no more alkali should be used than is necessary to hold the trivalent arsenic in solution.

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FURTHER STUDIES ON THE RELATIVE TOXICITY OF POISONS FOR GRASSHOPPER BAITS[1]

By CHARLES H. RICHARDSON and GEORGE A. THURBER, *Ames, Iowa*

ABSTRACT

Adult differential grasshoppers, *Melanoplus differentialis* (Thomas) were fed determined quantities of a standard bran-molasses bait which contained known concentrations of arsenious oxide, sodium fluoride, cuprous cyanide, zinc phosphide, sodium fluoaluminate, acid lead arsenate and nicotine tannate. The estimated M. L. D. of the first three compounds is 0.11 milligram per gram of body weight; for zinc phosphide it is 0.52 mg./gram. Acid lead arsenate is much less toxic, the M. L. D. being approximated as 2 to 4 mg./gram; sodium fluoaluminate is evidently less toxic than acid lead arsenate. Nicotine tannate has a low but undetermined toxicity for this insect. The toxicity of some of these compounds for other insects is discussed briefly. Cuprous cyanide and zinc phosphide seem worthy of further experimental investigation.

An investigation of poisons for grasshopper baits, initiated in the summer of 1931 (13) was continued during 1932. The purpose of this investigation has been to find a substance which can replace arsenious oxide either because it is more toxic to grasshoppers, has a lower toxicity to vertebrate animals, is available at reduced cost, or has some other advantageous property. Attention has also been given to information of general toxicological interest.

This paper contains a report upon the comparative toxicity in a standard bran-molasses bait of arsenious oxide, sodium fluoride, cuprous cyanide and zinc phosphide for the differential grasshopper, *Melanoplus differentialis* (Thomas). Less complete information is also included on the toxicity of sodium fluoaluminate (cryolite), acid lead arsenate, and nicotine tannate for the same insect.

MATERIALS.—Grasshopper nymphs which had hatched on the same day were reared in the greenhouse with fresh, young corn plants as their only food. When adult, they were practically free from diseases and parasites, and appeared to be otherwise normal except for a considerably reduced body weight. One hundred and twelve males weighed from 0.316 gram to 1.021 gram, with a mean of 0.619 gram; 129 females varied in weight from 0.378 gram to 1.647 gram with a mean of 0.743 gram. The mean weight of these males was only 72.5 per cent and that of the females only 52 per cent of the weight of the wild grasshoppers used in the 1931 experiments (13). The smaller weight of the females of the laboratory reared insects resulted in part from the fact that they were used before they had accumulated large quantities of storage substances.

[1]Journal Paper No. B 88 of the Iowa Agricultural Experiment Station.

Of the compounds employed in this investigation the sodium fluoride contained 99 per cent NaF, the cuprous cyanide 99.34 per cent CuCN, the sodium fluoaluminate 90+ per cent Na_3AlF_6, and the zinc phosphide 98.7 per cent of Zn_3P_2. The nicotine tannate was prepared from a sample of nicotine of 99 per cent purity and chemically pure tannic acid. The analyses of the acid lead arsenate and arsenious oxide, reported elsewhere (13), are comparable with those of the other compounds.

The bait mixtures were presented to the insects in small, Pyrex dishes about 7 mm. in height and 35 mm. in diameter which weighed about 15 grams. The dishes were fitted with ground glass covers to prevent loss of moisture from the bait during the weighing and transferring processes.

METHODS.—The bait mixtures were prepared according to the following formula: bran 25 grams, molasses, 6 grams, and water 34 grams. This differs from the formula used for the preparation of commercial baits principally in an increased water content. The quantity of poisonous compound was varied from 0 1 gram to 1.0 gram to facilitate control of the dosage.

An adult grasshopper, which had been starved overnight, was weighed, and was then placed in a moist-chamber with one of the small dishes described above which contained a weighed quantity of the bait. After the insect had eaten the desired quantity of bait, it was removed to a small cage, supplied with fresh, green, corn foliage and observed continuously during the day. The time at which an insect died during the night was estimated from a knowledge of its condition on the last observation in the evening and the flexibility of its body in the morning. All insects were maintained at room temperature (27° to 32.5° C.) throughout the period of observation.

Control insects from the same lot which furnished the experimental material accompanied each day's batch of treated insects. Of the 78 control insects used in these experiments, only 5.1 per cent died, all deaths occurring after at least 4 days. From the standpoint of viability, the insects seemed amply fit for the purpose.

RESULTS.—The results of the experiments with arsenious oxide, sodium fluoride, cuprous cyanide and zinc phosphide are summarized in Table 1. Experience with acid lead arsenate, sodium fluoaluminate and nicotine tannate was more limited and was inadequate as a basis for the estimation of the median lethal dose; however, the data are considered of sufficient interest to be summarized briefly here.

Acid lead arsenate was fed to 40 grasshoppers in doses varying from 0.72 to 7.68 mg./gram of body weight. Doses of 4.63 to 7.68 mg./gram, six in number, were lethal, death occurring in 49 to 110 hours, average 77 hours. Recovery doses fell in the range 0.72 to 4.18 mg./gram, but in this series 6 of the 34 insects succumbed at lower doses, i. e., within 1.58 to 3.78 mg./gram, their time variation being from 70 to 156 hours, average 110 hours. The median lethal dose (M. L. D.) for acid lead arsenate probably lies between 2 and 4 mg./gram.

TABLE 1. SUMMARY OF THE TOXICITY DATA (*M. differentialis*)

	Arsenious oxide	Sodium fluoride	Cuprous cyanide	Zinc phosphide
Lethal Zone				
Dosage range*	0.94–0.15	2.61–0.18	5.80–0.21	3.87–1.04
Range survival time in hours	32–84	22–101	18–107	22–59
Mean survival time in hours	56	61	57	37
Number insects	22	31	75	11
Intermediate Zone				
Dosage range*	0.14–0.05	0.17–0.07	0.20–0.08	0.77–0.33
Range survival time in hours	22–144	47–155	30–158	41 162
Mean survival time in hours	80 (86)	105 (86)	84 (86)	75 (86)
Number insects:				
Died	17	9	11	9
Recovered	14	5	8	7
Median lethal dose (M.L.D.)*	0.09(.11)	0.11(.11)	0.13(.11)	0.52
Mean dosage which killed*	0.10	0.11	0.13	0.53
Mean recovery dosage*	0.08	0.11	0.14	0.50
Sub-Lethal Zone				
Dosage range*	0.04–0.02	0.06–0.04	0.07–0.03	0.30–0.17
Number insects	4	6	6	6

*Dosages are given in mg. poison per gram of body weight of the insect.

Sodium fluoaluminate is apparently even less toxic than acid lead arsenate to this insect. The doses ingested by 24 individuals varied from 0.36 to 7.19 mg./gram, and recovery occurred from the six highest doses administered. Only 6 individuals died from doses ranging from 0.36 to 3.98 mg./gram, average 2.32 mg./gram. The times were 40 to 101 hours, average 61 hours. The M. L. D. cannot be approximated from this series but it is undoubtedly very high.

Ten grasshoppers were fed nicotine tannate in doses from 0.35 to 4.14 mg./gram. There were 8 recoveries from doses of 0.35 to 2.88 mg./gram and two deaths in 65 and 141 hours from 4.14 mg./gram and 1.75 mg./gram respectively. This inadequate series serves to show that nicotine tannate is only slightly toxic to this insect.

The mean dosages of the intermediate zones for the four compounds chiefly concerned in this study are given in Table 1. Statistical analysis by a small sample method (13) of the mean recovery dosage and the mean dosage which killed within the intermediate zone of each compound, shows that these two values differ significantly neither from

each other nor from the mean dosage of the entire zone. Therefore the mean of all doses within the intermediate zone is taken as the best available criterion of the M. L. D. of each compound. On this basis, the M. L. Ds of the four compounds give the following ratios: arsenious oxide, 1.00, sodium fluoride, 0.82, cuprous cyanide, 0.70, and zinc phosphide, 0.17. When the M. L. Ds of the first 3 compounds are statistically compared, it is found that they are not significantly distinct, that as great variation in the M. L. Ds could reasonably well be expected if the three groups of insects had been fed the same poison. The means of the M. L. Ds for arsenious oxide, sodium fluoride and cuprous cyanide are therefore averaged to give 0.11 mg. /gram as the best estimate of the M. L. D. for these compounds. More abundant data would probably show small, though significant differences between them. The M. L. D. of zinc phosphide is very distinct from that of the 3 compounds above mentioned.

In this treatment of the toxicity data, the figures have been arrayed according to dosage whereas in our previous publications (12, 13) they have been grouped under corresponding time survival groups. If the toxicity figures are sufficiently numerous and form a continuous series, treatment by either of these schemes will lead to the same result. In small samples, however, upon which one is often forced to rely, the chance grouping of the data sometimes favors one scheme of treatment over the other. The present data seem best treated as indicated above although by the method of arrangement in time survival groups the following M. L. Ds in mg. per gram were obtained. arsenious oxide, 0.08, sodium fluoride, 0.10, cuprous cyanide, 0.14, zinc phosphide, 0.39. The first 3 figures correspond closely with the respective M. L. Ds in Table 1; the agreement of the figures for zinc phosphide is less satisfactory, the result, undoubtedly, of the small number of dosage values available.

Differences between the mean survival times of the four compounds in the intermediate zone (Table 1) show, at most, doubtful significance ($P = 0.1$ to 0.7); and in view of the fact that the time data are less accurate than the dosage data, the four means are averaged giving 86 hours as an estimate of the survival time. On the basis of this analysis, the speed of toxic action of the four compounds is similar, and the M. L. Ds of arsenious oxide, sodium fluoride and cuprous cyanide are alike, but the M. L. D. of zinc phosphide is distinctly larger. In order to detect any unusual effects of these compounds at higher dosages (lethal zone), the percentage of deaths which occurred in each 24-hour period was computed. Sixty per cent of the deaths from zinc phosphide

occurred in the second 24-hour period; cuprous cyanide ranked second with 34 per cent, whereas arsenious oxide and sodium fluoride had 28 per cent and 22 per cent deaths respectively in this period. It is possible that zinc phosphide tends to kill more quickly at high dosage than the other compounds although it should be noted that the dosage ranges in the lethal zone for zinc phosphide and cuprous cyanide are higher than are those of the other compounds. The data from the zinc phosphide tests are suggestive but are insufficient to determine this point.

Discussion.—The M. L. D. of cuprous cyanide determined by Campbell and Filmer (3) is 0.04 mg./gram for the fourth instar silkworm (*Bombyx mori* L.). More recently, Bulger (2) has found it slightly more toxic to the catalpa sphinx (*Ceratomia catalpae* Bdv.), the M. L. D. being 0.025 mg./gram. Our experiments indicate that it is about as toxic as arsenious oxide to the differential grasshopper, an insect which appears to be more resistant to several arsenical compounds than the lepidopterous and coleopterous larvae heretofore tested by precise methods. In contrast, Campbell (4) reports the M. L. D. of arsenious oxide for the silkworm as between 0.015 and 0.020 mg./gram, indicating that it is somewhat more toxic than cuprous cyanide to this insect. Although it probably cannot take the place of the cheaper arsenicals in baits, the high toxicity of cuprous cyanide recommends it for further consideration (5, 10) in the experimental control of the more resistant species, especially in situations where the soluble arsenicals or the less toxic acid lead arsenate are not suitable. The availability of cuprous cyanide of high purity and adaptability for use in sprays and dusts affords an opportunity to obtain more complete information concerning its effects upon foliage and also upon the toxicity of the spray residues to higher animals.

Although zinc phosphide has been used in Europe at least since 1919 (11), and has shown considerable merit in baits for crickets Malenotti (7, 8); Maylin (9); Aurivel (1), it is not well known in America. It is a crystalline, friable compound, with metallic luster, and a specific gravity of 4.55 to 4.76, but it may also be obtained in a pulverized condition. Its solubility in water and in alcohol is negligible though strong acids dissolve it with the evolution of phosphine. Malenotti (6) states that vegetation which has been sprayed with it in control operations for grasshoppers, is not injured.

Our results indicate that zinc phosphide is about one-fifth as toxic as arsenious oxide though still much more toxic than acid lead arsenate to the differential grasshopper. Low solubility in water and a fair degree of toxicity to a resistant insect recommend it for further experimental trial.

A quantitative estimate of the toxicity of sodium fluoride by precise methods has apparently not been published. The above described tests show that it has about the same M. L. D. as arsenious oxide for this species. The value is similar to the M. L. D. of sodium fluosilicate for *M. femur-rubrum* (DeG.)

The M. L. D. of arsenious oxide for *M. differentialis* is about one-third the value reported recently (13) for *M. femur-rubrum*. The difference may be statistical as the value for the latter species is admittedly an approximation based upon inadequate data. It may also be due in part to differences in the species, to the nutritional condition of the populations from which the respective insect samples were drawn, or to other causes. It is interesting to note in this connection that the M. L. Ds of the soluble arsenites for *femur-rubrum* are similar to that of arsenious oxide for *differentialis*.

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*Cited from the Review of Applied Entomology. The original was not seen.

THE RELATIVE TOXICITY OF NICOTINE, ANABASINE, METHYL ANABASINE, AND LUPININE FOR CULICINE MOSQUITO LARVAE

By F. L. Campbell and W. N. Sullivan, *Bureau of Entomology*, and C. R. Smith, *Bureau of Chemistry and Soils, U. S. Department of Agriculture*

Abstract

Based on concentration required to kill 50 per cent of a population of culicine mosquito larvae in 8 hours at 29.3°C., the relative toxicity of four alkaloids is as follows: nicotine 100, anabasine 38, methyl anabasine 21, and lupinine 6 (?). According to unpublished observations of others, nicotine and anabasine may be equally effective against aphids. Nicotine and anabasine are much less toxic than rotenone against mosquito larvae and house flies.

Methods for preparing the alkaloids and for obtaining, rearing, counting, and transferring mosquito larvae are described.

The purpose of this paper is to describe certain methods that were found convenient for obtaining and using culicine mosquito larvae as test insects for insecticides, and to give the results of comparative tests of certain alkaloids related to nicotine. These alkaloids, i. e., anabasine, methyl anabasine, and lupinine, were prepared from a commercial sample of "anabasine sulphate, 40 per cent" imported from the U. S. S. R. This commercial product was obtained from a Russian weed, *Anabasis aphylla* L. Anabasine is of particular interest because it is identical, except in optical activity, with synthetic neonicotine (*5*), which was found by Smith, Richardson, and Shepard (*6*) to be as toxic for *Aphis rumicis* as nicotine.

Chemical Materials and Methods.—The first samples of "anabasine sulphate" received by the Insecticide Division, Bureau of Chemistry and Soils, were found to contain not only anabasine but also methyl anabasine and possibly small quantities of other low-boiling alkaloids besides lupinine, which boils at 270°C. Recent samples of "anabasine sulphate, 40 per cent" were found to contain 40 per cent of total alkaloids, of which 72 per cent was anabasine (levo-neonicotine), 18 per cent lupinine, and about 10 per cent higher alkaloids boiling much above 281°C., the boiling point of anabasine. The alkaloids used in the present tests were prepared from one of the recent samples as follows:

The total alkaloids of the "anabasine sulphate" were freed by treatment with strong alkali. The mixed alkaloids separated on standing in a separatory funnel. After removal of the alkali layer, ether was added to facilitate the complete removal of the total alkaloids. The ethereal solution was first dried completely by standing it over lumps of potash, then the ether was removed by evaporation on the steam bath, and the

residue of alkaloids was distilled under vacuum, leaving behind only a little basic tar. The distilled bases were mixed with water and dissolved by means of hydrochloric acid, which was added until the solution was just acid to litmus paper.

Anabasine appeared to be the only alkaloid present with a free imino group and was therefore readily separated by the addition of sodium nitrite in excess. The nitroso-anabasine separated completely as an oil and was removed mechanically. Although ether is not a good solvent for nitroso-anabasine, the addition of a small quantity facilitated separation of the two layers. After the ether had been removed, the nitroso-anabasine was converted into anabasine by treatment with excess of concentrated hydrochloric acid and heating it on the steam bath for several hours. The anabasine was recovered by treatment with alkali, extraction with ether, and distillation in the usual manner.

Anabasine thus obtained boiled between 280.6 and 281.4°C. (cor.) and gave a picrate which after one crystallization melted sharply at 213°C. The anabasine was undoubtedly very pure. Anabasine is soluble in water in all proportions at all temperatures and, in contrast with nicotine, is only slightly volatile with steam

The acid layer from which the nitroso-anabasine was separated was used for the preparation of the lupinine. The acid solution was made alkaline, and extracted with ether, the ethereal solution dried, the ether removed by evaporation, and the alkaloidal residue distilled in vacuo.

The lupinine and high boiling alkaloids were contained in this fraction and were separated by distillation at atmospheric pressure, the fraction below 280°C. being collected for lupinine. The lupinine crystallized out in a solid mass and was purified by crystallization from petroleum ether. Pure lupinine melts at 69°C. and boils at about 270°C. Lupinine occurs in certain plants growing on the ranges of the Southwest and has been found poisonous to grazing livestock.

Since the sample of "anabasine sulphate" used in this work did not contain methyl anabasine, this product was made by methylation of anabasine by means of dimethyl sulphate in the usual manner. To assure the absence of unaltered anabasine, the nitrous acid method was used to separate the anabasine, and the methyl anabasine was obtained from the acid liquid. Methyl anabasine boils at about 270°C. and is soluble in cold water in all proportions. Concentrated solutions on warming form two layers just as do nicotine and other compounds with the N-CH_3 group.

ENTOMOLOGICAL MATERIALS AND METHODS.—Two series of tests were made, one in September with larvae from eggs collected on the grounds

of the Takoma Park, Md., station, and the other in November with larvae from eggs sent to this station from the Bureau laboratory at Orlando, Fla., through the kindness of F. C. Bishopp and G. H. Bradley.

The local eggs were collected daily from a small natural pool in a sheltered spot, and also from jars and pans containing water and decaying leaves. The eggs were placed on the surface of water in 6-inch battery jars, from 3 to 6 egg masses per jar. To each jar nearly full of water 50 cc. of yeast suspension was added from a stock suspension containing one-half pound of baker's yeast per liter of water. The jars were left uncovered in a screened outdoor insectary. Under these conditions the larvae developed satisfactorily in most jars and reached the fourth instar in 5 to 9 days, when they were used for the tests.

Contrary to the experience of Marcovitch (*2*), the writers found yeast more satisfactory for the rearing of mosquito larvae than dried blood. Although detrimental scum formation did occur in some of the yeast cultures, it always occurred in dried-blood cultures accompanied by obnoxious odors. The course of decomposition of the cultures was undoubtedly dependent on the types of nicroorganisms that happened to lodge and develop in them. Most of the yeast cultures did not change in appearance during the development of the larvae. Some turned green and others red without injury to the larvae. Even in the cultures that did not turn red or green, many of the mature larvae were distinctly colored pink, orange, green, blue, or violet. Several samples of adults from local larvae were examined by Alan Stone, of the Bureau of Entomology. *Culex pipiens* L. and *C. territans* Walk. were found. One or the other or both species may have been used in these tests.

The Florida eggs were sent to the writers daily by air mail. They were placed on cheesecloth over moist cotton in pill boxes. The eggs arrived unhatched within 48 hours after they were laid. The egg masses were considerably broken up in transit, but the eggs were apparently not injured. The same culture medium was used as for the local larvae, but the jars were kept indoors and were covered with cheesecloth. An excellent hatch of eggs was always obtained, though as the weather grew colder the period of hatching increased and the resulting larvae were not so uniform in size. The larvae grew even better than they did in the insectary. Some jars must have contained from 3,000 to 4,000 larvae, which when nearly mature covered the entire surface of the medium. Yet they throve under the apparently crowded conditions, indicating that the quantity of yeast added to each jar was usually greater than necessary. Scum formation rarely occurred in the laboratory and none of the cultures changed color. No colored larvae were

observed. According to G. H. Bradley, *Culex quinquefasciatus* Say was the species sent from Florida.

Both local and Florida larvae were handled in the following manner: Fourth-instar larvae in one or more jars were strained out by the use of a circular, flat, cheesecloth net. The net was sewed on a circle of heavy wire, which was held by two straight pieces of wire hinged to opposite points of the circumference. The wire circle fitted the inside circumference of the jar. The net was lowered into the jar vertically, and after the larvae came to the surface it was quickly turned horizontally within the liquid and lifted out, thus trapping the larvae and straining them out. The larvae were removed from the net immediately by bringing the side bearing them in contact with shallow water in a 4-quart white-enameled milk pan. When larvae were taken from more than one jar, they were mixed in the pan before further transfers were made. Since 100 larvae were drawn at random from the mixture for each test and since all compounds to be compared were always tested simultaneously, it was immaterial for our purpose that more than one species may have been present or that the larvae may not have been uniform in size.

The larvae were counted out in lots of 100 with the aid of a pipette designed for the purpose It was made from a 10-inch piece of glass tubing (2 mm. inside diam.). One end was flared to 4 mm., and a bulb was blown near the other end The bulb was packed loosely with cotton to prevent the larvae from being sucked out of the glass tube and into a rubber tube that was attached to it. By a sweep of the flared end of the tube just under the surface of the water in the milk pan and with simultaneous suction on the rubber tube, water containing larvae was drawn up into the pipette. The diameter of the tube was such that the larvae were distributed along its length almost in single file. Although they had room to wriggle, they could not readily pass one another, and it was possible to count rapidly from 15 to 25 larvae at a time in spite of their movements. The counted larvae were transferred to small beakers of water, 100 larvae to a beaker. Up to this point the procedure was the same as that used in tests of rotenone and related compounds that were exposed to light (*1*).

The tests were made in 125 cc. Erlenmeyer flasks containing 100 cc. of solution. In order to transfer the larvae from the beakers to the solution in the flasks two slightly different methods were used. The local larvae were poured out upon a piece of cheesecloth stretched loosely over a 2½ inch glass funnel. After they were washed with water from a wash bottle, the cloth was turned over on the funnel and the larvae, now cling-

ing to the under side, were washed through the funnel into an empty flask by pouring through the cheesecloth part of the solution to be tested. The remainder of the solution was added directly to the flask. The Florida larvae were filtered and washed in the same way, but the wet chesecloth bearing the larvae was then wrapped about the rounded end of a test tube in such a way that the larvae occupied a smooth area on the outside of the cloth The tube was then dipped into the solution in the flask and the larvae swam away immediately. With this method the flasks could be placed in the water bath (29.3 ± 0.1°C.) and the larvae added later without removing the flasks from the bath. The latter method was also more satisfactory in other respects and could be used with suspensions as well as with solutions.

Effect of the Alkaloids.—The behavior of mosquito larvae in solutions of nicotine has been described by Richardson and Shepard (3). In preliminary experiments to determine suitable concentrations for comparative tests, the present writers noted the rapid and violent effect of nicotine as opposed to the slow and mild effect of rotenone. Nicotine at any concentration that failed to kill all the larvae exerted nearly all its lethal effect in the first half hour of the test. Larvae that withstood the initial action seemed to become accustomed to the environment, behaved normally, and lived indefinitely. Anabasine and methyl anasbasine did not effect the larvae as rapidly and violently as nicotine and the period during which deaths occurred was longer. The action of lupinine was even more mild and slow.

Owing to the commotion caused by nicotine among the larvae, it was impossible to determine the time at which half the larvae were unable to reach the surface, the end point chosen in tests of rotenone. It seemed best to determine the number of dead and moribund larvae at the end of a period of time sufficient to permit all four alkaloids to produce their maximum effects at the concentrations chosen. Preliminaty tests indicated that the number "down" at the end of eight hours would be satisfactory.

Relative Toxicity of the Alkaloids.—The results of 3 series of tests against local larvae and 8 series of tests against Florida larvae are given in Table 1. The average mortality in all tests is plotted against concentration in Figure 41. The concentrations of the alkaloids, except lupinine, were chosen so that one would give more than a 50 per cent kill and another less. The quantity of lupinine available was insufficient to permit the use of concentrations high enough to kill 50 per cent or more and only 5 instead of 11 series of tests could be made with lower concentrations. Water checks were not included in these tests, because the mortality was negligible in the dozens of checks that were run previously.

Since only three concentrations of nicotine, anabasine, and methyl anabasine were tested, the points in Figure 41 are too few to describe the true shape of the curves. It was not our purpose, however, to obtain and study sigmoid curves, but rather to determine by repetition of tests and

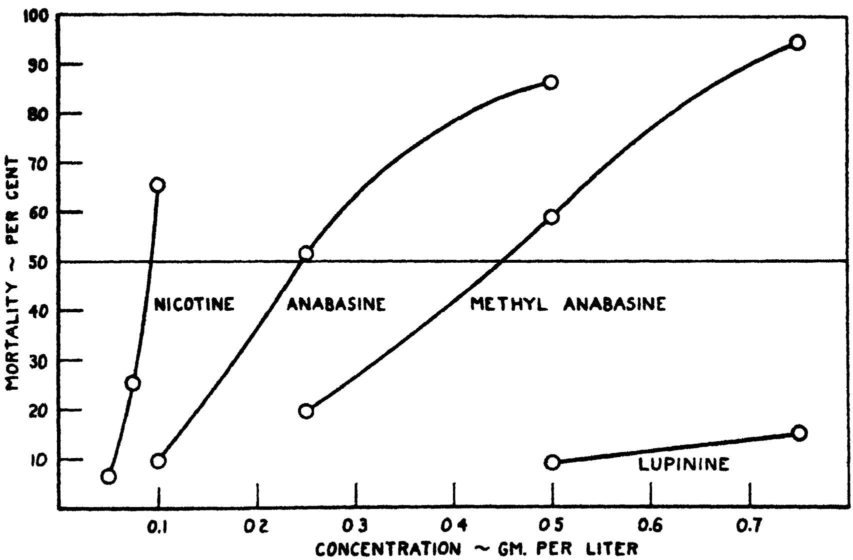

FIG. 41.—Relation of concentration of four alkaloids to mortality of mosquito larvae after 8 hours at 29.3 ± 0.1°C. The figures given for mortality include those for dead and moribund larvae.

by graphical interpolation the approximate concentrations required to kill 50 per cent of the larvae. From Figure 41 these concentrations are: nicotine 0.093, anabasine 0.245, and methyl anabasine 0.45 gram per liter. One test of lupinine at 2 grams per liter indicated that the concentration required to kill 50 per cent in 8 hours might be about 1.5 grams per liter. Calling the effect of nicotine 100, the relative toxicity or relative effectiveness of the four alkaloids under the conditions of these tests is as follows: nicotine 100, anabasine 38, methyl anabasine 21, and lupinine 6 (?). Every series of tests placed the alkaloids in the order just given. The numerical relationships are, of course, not so sure, but nicotine is certainly more than twice as toxic as anabasine for culicine mosquito larvae by the criterion adopted.

The average mortalities of local and Florida larvae are given in Table 1. They agree well enough to support the conclusion that the relative effect of the alkaloids was much the same on the two or more species that were used.

Table 1. Number of Mosquito Larvae "Down" After 8 Hours in Solutions of Nicotine, Anabasine, Methyl Anabasine, and Lupinine at 29.3±0.1°C., 100 Larvae per Test

	Nicotine			Anabasine			Methyl anabasine			Lupinine	
	Gm. per liter, 0.1	Gm. per liter, 0.075	Gm. per liter, 0.05	Gm. per liter, 0.5	Gm. per liter, 0.25	Gm. per liter, 0.1	Gm. per liter, 0.75	Gm. per liter, 0.5	Gm. per liter, 0.25	Gm. per liter, 0.75	Gm. per liter, 0.5
	100	34	23	77	36	10	94	59	26	19	5
Number of local larvae down......	75	47	19	85	68	24	96	61	39	—	—
	35	29	6	63	31	11	85	61	6	9	2
Average.....................	70.0	36.7	16.0	75.0	45.0	15.0	91.7	60.3	23.7	14.0	3.5
	72	16	6	89	60	20	97	53	5	13	8
	67	19	5	85	41	5	96	44	10	—	—
	69	11	3	81	42	4	86	40	11	11	5
Number of Florida larvae down ...	60	23	4	83	41	5	99	50	6	—	—
	61	19	1	99	63	6	100	81	38	23	25
	60	32	0	100	66	5	94	71	34	—	—
	57	17	3	91	57	7	97	74	24	—	—
	65	31	1	96	64	10	95	54	17	—	—
Average.................. ..	63.9	21.0	2.9	90.5	54.2	7.7	95.5	58.4	18.1	15.7	12.7
Grand average.............. ...	65.5	25.3	6.5	86.3	51.7	9.7	94.5	58.9	19.6	15.0	9.0

DISCUSSION.—The possibilities of new insecticides, such as anabasine or rotenone, can not be considered adequately explored until they have been tested against many species of insects under many conditions. The present results are therefore to be regarded as a very small but definite contribution, which alone does not indicate the practical possibilities of anabasine as a nicotine substitute, but which may prove useful when added to the data that are likely to be secured later.

Through the kindness of W. S. Abbott, in charge of the Silver Spring, Md., testing laboratory of the Food and Drug Administration, the writers were permitted to see and to comment on unpublished data secured by G. D. Reynolds and S. C. Billings, who tested anabasine and commercial anabasine sulphate against 5 species of aphids at various concentrations. Although nicotine was not tested in direct comparison, they believe that anabasine is as good an aphicide as nicotine.

The following results, which have not been published, were obtained in the State of Washington by M. A. Yothers and E. J. Newcomer, of the Bureau of Entomology, cooperating independently with S. W. Griffin, C. W. Murray, and J. E. Fahey, of the Bureau of Chemistry and Soils.

Yothers compared commercial anabasine sulphate, 40 per cent, and commercial nicotine sulphate, 40 per cent, both at 1:1,600 in a 1 per cent mineral oil emulsion. Apple shoots infested with the apple aphid were sprayed with these mixtures and were placed in a cage where they were left until the counts were made two days later. Anabasine sulphate-mineral oil emulsion killed all of 2,340 aphids. Nicotine sulphate-mineral oil emulsion killed 98.3 per cent of 3,535 aphids. The mineral oil emulsion alone killed 78.3 per cent of 2,055 aphids.

Newcomer compared two samples of commercial anabasine sulphate, 40 per cent, with one sample of commercial nicotine sulphate, 40 per cent, all at 1:1,600 in a 1 per cent mineral oil emulsion. The tests were made in June against newly hatched codling moth larvae. Each mixture was sprayed on two sets of 5 apples. One set was tested immediately after spraying and the other a week after spraying. Ten larvae were placed on each apple. In the "immediate" tests 58 and 70 per cent of the larvae entered the apples treated with anabasine sulphate, 32 per cent entered those treated with nicotine sulphate, and 84 per cent entered the check apples. In the "delayed" tests the percentages of entrances were as follows: anabasine sulphate 88 and 80, nicotine sulphate 82, check 92. The tests were repeated later in the summer with essentially the same results.

The present writers made one series of tests of nicotine, anabasine, methyl anabasine, and lupinine against house flies. Solutions of the alkaloids in absolute ethyl alcohol (1.0 gm. per liter) were sprayed on the flies in a screen-covered Petri dish at the bottom of a cylindrical glass spraying chamber. Since none of the alkaloids affected the flies, it does not seem necessary to give here a detailed account of the procedure. It is sufficient to say that rotenone (0.1 gm. per liter), applied in exactly the same way, usually killed more than 50 per cent of the flies. Nicotine in water with saponin as a spreader was sprayed on house flies at higher concentrations At 2 gm. per liter it had no effect. At 10 gm. per liter it had a temporary effect. About 15 minutes after the treatment nearly all the 50 flies were down. Some of them were able to walk, but walked backward as well as forward and also in circles, pivoting on the hind legs. In less than an hour after the treatment every fly was normal and able to drink milk. If nicotine had been a new compound, the writers might have concluded that its toxicity was so low as to make it unworthy of further tests as a contact poison These results with house flies show the danger of discarding a substance because it fails against one species of insect.

Tests against mosquito larvae as well as those against house flies showed that rotenone is much more toxic than nicotine. Although Shepard (*4*) also found that rotenone is more toxic than nicotine for mosquito larvae, he did not do justice to rotenone, because he compared the two compounds at only one concentration, 0.1 gm. per liter (1:10,000). As shown in the present paper, nicotine is not effective at concentrations slightly below 0 1 gm per liter, whereas rotenone is as effective at 0.005 gm. per liter as it is at 0.1 gm. per liter (*1*).

The normal behavior of larvae surviving in 1:10,000 solutions of nicotine made it seem possible that the concentration of the solutions might have been reduced by the larvae, perhaps by adsorption. Accordingly 100 cc. of a 1.10,000 solution of nicotine were placed in each of four Erlenmeyer flasks To each of three of them 100 mosquito larvae were added and the fourth was kept stoppered without larvae as a check. At the end of 9 hours 75, 80, and 86 larvae were down. All larvae were then filtered out on cheesecloth, and the three test solutions and the check were sent for analysis to H. D. Young, Insecticide Division, Bureau of Chemistry and Soils. He found 9.30 mg. of nicotine in the check and 9.29, 9.39, and 9.38 mg. in the solutions in which larvae had died. In other words, the larvae did not remove a detectable quantity of nicotine from the solutions, and the survivors, therefore, were apparently able to accustom themselves to the original concentration

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Scientific Notes

Injury to Carrot, *Daucus carota*, by *Trifidaphis phaseoli* (Pass.). While working with subterranean aphids in 1923–24 and '25, the writer collected *T. phaseoli* from a number of different hosts. Although a considerable amount of collecting was done in vegetable gardens, this aphid was not taken from carrots at that time. During the past 2 years the species has been collected several times from carrots and other inquiries concerning injury to this plant have been received. Severe injury to the carrot root may be caused by the presence of even a few lice. If the aphids are located on the sides of the root, large depressions occur, while if the infestation is about the growing tip, normal growth is stopped and several branching, almost fibrous, roots may result. To date all such reports and collections have come from the hill sections of the upper Ohio Valley.

C. R. CUTRIGHT, *Associate Entomologist, Ohio Agr. Experiment Station, Wooster, Ohio*

The Lesser Apple Worm (*Grapholitha prunivora* Walsh) in California. The larvae of this moth occur in wild rose haws and Toyon (*Photinia*) berries in various sections of the northern part of this State. The State Department of Agriculture has the following records of this species: larvae from rose haws, August 21, 1929, near Vacaville (Keifer), adults September 21, 1929; larvae from Toyon berries at Forest Hill, Placer County, September 8, 1929 (E. Gammon), adults November 16, 1929; larvae from rose haws near Marysville, October 6, 1930 (Carter), adults November 4, 1930. The writer has also noted these larvae in rose haws near Palo Alto. We have no records of the species as an orchard pest in the State. The authentication of the name is by Mr. Carl Heinrich.

H. H. KEIFER, *State Department of Agriculture, Sacramento, California*

***Thylodrias contractus* Mots.**, a Dermestid-like insect has recently been taken from a dwelling in Chicago. This pest, apparently introduced from Europe, was first recorded in the United States in 1902, New York City. Felt reported its occurrence, in New York State Museum Report 31, 1916, and New York State Museum Bulletin 194, 1917, and Weiss has reported it in New Jersey Department of Agriculture

Circular 108. The insect is reported *in Chicago* as having been first found a year and a half ago in miscellaneous packages containing wedding presents. It appears to be most prevalent among tissue paper. No damage from the insect has been noted but its persistence and occurrence everywhere have been most annoying. The Dermestid-like larvae roll themselves into a ball when disturbed and can be distinguished from other Dermestid larvae by the single transverse row of erect clavate and spiny hairs that crosses the dorsum of each principal segment. Böving and Craighead give a good figure of the larva in "Entomologica Americana," Vol. XI, No. 4, plate 90, 1931, and Weiss figures the adult male and female as well as other stages in New Jersey Department of Agriculture Circular No. 108.

C. L. METCALF

The Beech Scale and a Fungus. The investigations of Mr. John Ehrlich, as published in Phytopathology, show a very interesting connection between this scale insect, *Cryptococcus fagi*, and a deadly fungus, provisionally identified as *Nectria coccinea*. He states that a survey in the affected regions, Maine and the Maritime Provinces of Canada, shows that approximately 90% of the beeches in forest stands and with a trunk diameter of over three inches are infected with this fungus and that approximately 50% are already dead where the attack has continued for several years. Field observations, inoculations, and other experiments, and histological studies show that the fungus enters the minutely fissured periderm of the trunk and branches where the scale insect has been feeding and goes rapidly through the bark into the cambium and peripheral sapwood, causing the death of these tissues. Both the fungus and the insect are distributed by wind, the fungal spores during and after rain, and the insect during egg and larval stages in summer and autumn. The fungus is spreading southward and westward and has been found in Maine, and the insect located as far south as Boston, Mass. The control of the insect on ornamental trees is the most feasible method of preventing damage by this associated fungous disease.

E. P. FELT

Sitotroga Production. A production unit set up in a manner somewhat like that described on page 1008, Vol. 23, of the Journal, and holding two-thirds of a ton of corn, was operated for a period of over five months. An egg production in excess of 12,000,000 was obtained from the moths produced. The monthly egg production was approximately as follows:

September	1,000,000
October	4,000,000
November	4,000,000
December	2,000,000
January	1,000,000

The corn was packed in ten bins, each bin measuring 36 x 30 x 5 inches. Instead of using a funnel, as previously described, a tube 1¼ inch in diameter was substituted. On the top side of the tube was a slot 1/16 inch wide opening into a cloth enclosure. Connected in line with this tube was an electric hair dryer and a moth receptacle consisting of a one-gallon glass jar with a screw top.

The moths leave the grain and for the most part concentrate on the cloth in areas where they are subjected to optimum pressure from a constant air current which enters the enclosure through a slot ¼ inch in width extending along the top of the enclosure. In collecting the moths the air pressure is not cut off, as previously sug-

gested, but the operator strikes the cloth several times to dislodge the moths resting on its inner surface. The moths drop to the V-shaped bottom of the enclosure, slip through the slot into the suction tube, and are carried to the moth receptacle.

Collections are made once or twice daily, depending on moth emergence. The time required for each collection is about one minute. After each collection the jar is disconnected, a 20-mesh screen cover is screwed into position, and the jar then inverted over a trough for egg deposition. An air current from an electric fan carries away the scale dust.

STANLEY E. FLANDERS, *University of California Citrus Experiment Station, Riverside, California*

Some Early Observations Concerning Trichogramma. In 1895, at a meeting of the South London Entomological Natural History Society, Mr. Enock exhibited and described at some length the egg-parasite, *Trichogramma*. He stated that he had made some 180 drawings of the various details of its history and structure. He then called attention to the economic benefit if the farming of this minute creature was carried out on a large scale.

Maxwell-Lefroy, in 1899, wrote an excellent treatise on the ecology of *Trichogramma* in relation to its host, *Diatraea*, in the Barbados Islands. He presented the hypothesis that as the growth of the sugar cane increases, *Trichogramma* has an increasingly greater difficulty in finding the eggs of the cane borer. For the control of this moth he recommended collecting the eggs from young cane and only incidental to that placing the eggs so that the *Trichogramma* could develop to maturity and escape to the fields. He found that during April and May the moth deposited an average of 100 egg clusters per acre per week, and sometimes during May the parasitism exceeded 75 per cent; about one-fifth of all the parasitized egg clusters however were not entirely parasitized. He emphasized the fact that great numbers of eggs would be left unparasitized, implying that it was not the percentage of parasitism that was important.

While working with the yellow form of *Trichogramma* in Texas, in 1904, Girault found that in the fall dark forms were produced, and as the weather became colder their numbers increased in proportion to the lighter forms. While working at its life history he found that it does not oviposit in the host egg after the egg turns black; that it develops in infertile host eggs; that it may reproduce parthenogenetically, but that usually the proportion of sexes are equal; and that it apparently hibernates in the pupal stage.

STANLEY E. FLANDERS, *Univ. of California Experiment Station, Riverside, California*

Worn-Out Motor Oil for the Control of the San Jose Scale. Southern peach growers have inquired frequently concerning the value of oil drained from the crank case of automobiles and tractors for the control of the San Jose scale. In order to answer these inquiries, experiments with worn-out motor oils emulsified with calcium caseinate were conducted during the winter of 1931–32, the results of which are given in the following table.

These results indicate that worn-out oils from the crank case of automobiles will give very good control of the San Jose scale, provided the oil is completely emulsified and the emulsion is fairly stable. It was necessary to use a little more of the calcium caseinate to obtain a fairly stable emulsion of oil from the crank case of an automobile than is required for the emulsification of new lubricating oil. Growers who desire to

use worn-out oils for spraying fruit trees for the San Jose scale should dilute them to a 4 per cent strength. There was no tree injury associated with the treatments reported above. Observations for tree injury were made semimonthly until May 23.

RESULTS OF EXPERIMENTS WITH EMULSIONS OF WORN-OUT CRANK CASE-OILS FOR THE CONTROL OF THE SAN JOSE SCALE ON PEACH TREES, FORT VALLEY, GEORGIA, WINTER OF 1931–32

Date of treatment	Strength of emulsion (per cent)	Average percentage of scale alive before spraying	Average percentage of scale alive one month after spraying	Per cent control obtained from worn-out motor oil emulsion
December 16 .	3	89.5 ± 0.85	9.0 ± 1.18	90.2 ± 1.3
December 16 .	4	94.2 ± 0.63	8.8 ± 2.26	90.9 ± 2.6
December 16. .	5	90.8 ± 1.49	1.7 ± 0.62	98.2 ± 0.5
Check—untreated		86.3 ± 1.58	88.7 ± 0.49	
January 20 . . .	4	88.2 ± 2.19	2.0 ± 1.0	97.6 ± 1.1
Check—untreated		88.7 ± 0.49	86.5 ± 0.4	
February 23[1]. . .	3	87.0 ± 0.3	8.0 ± 1.7	90.0 ± 2.0
Check—untreated		85.5	79.0	
February 23[2].. ...	3	93.3 ± 1.5	10.0 ± 1.3	89.1 ± 1.4
Check—untreated		92.0	90.5	

[1]Mixture of several worn-out oils emulsified with the usual quantity of emulsifier.
[2]Mixture of several worn-out oils emulsified with an excess of emulsifier.

OLIVER I. SNAPP and J. R. THOMSON, *U. S. Bureau of Entomology, Peach Insect Laboratory, Fort Valley, Ga.*

Naphthalene for Midge Larvae in Tobacco Seed Beds. Tobacco seed beds in parts of North Carolina have been badly infested for the last two years with a species of small midge. The worm-like white larvae occur in the early spring when the seeds are germinating. In some beds they appear in such numbers that the upper layer of soil is pulverized and loosened up so as to interfere with the rooting of the young seedlings. Early in March of this year C. H. Brannon and the writer looked at a seed bed near Lumberton, N. C., which the owner, Mr. Ira Kinlaw, had sprinkled with flake naphthalene. We were surprised to find thousands of midge larvae lying on the top of the ground apparently dead. Very few adult midges were present under the cloth. In an adjacent untreated bed the larvae were quite active and swarms of midges came out when the cloth was raised. There was no apparent injury to the plants in the treated bed.

A supply of infested soil was taken to Raleigh and divided equally between six gallon jars. A pinch of naphthalene was scattered over the soil in one jar, another was used as a check and the other four treated with calomel, Sentene, barium fluosilicate and paradichlorobenzene. All were covered with cheese cloth and adult midges were counted daily for 13 days. The total number of midges emerging was as follows: naphthalene 45, calomel 100, Sentene 248, barium fluosilicate 1021, paradichlorobenzene 689, check 795. In the naphthalene experiment only one midge emerged while the naphthalene was present. Two days after the naphthalene had evaporated two midges appeared and 42 came out during the next three days. With the calomel experiment 93 midges appeared during the first two days and only 7 during the remaining period. It would appear that naphthalene was more toxic to the older larvae and calomel more toxic to the younger larvae.

Naphthalene was applied to young tobacco seedlings in cloth covered jars at rates equivalent to 1½, 3, 10 and 20 pounds to 100 square yards. In the two jars receiving the heaviest dosage the plants died after several days, but in the other two

jars most of them were living after the naphthalene had evaporated. In a tobacco bed the gas would diffuse more rapidly than in the jars but 1½ pounds to 100 square yards has been found to give satisfactory control of the midge. Additional applications may be necessary as the material evaporates, while the plants are still small. Several tons of Naphthalene have been sold in two counties where the midge has been most abundant this year and no injurious effect on the plants has been reported.

B. B. FULTON, *N. C. Experiment Station, Raleigh, N. C.*

Parasite Reared from the Elm Leaf Beetle and the Imported Willow Leaf Beetle. During 1932 members of the Melrose Highlands, Mass., station of the Division of Forest Insects, U. S. Bureau of Entomology, reared two parasites that, so far as is known, have not been previously recorded from the United States. Both are apparently important parasites of two injurious insect pests in New England.

Larvae and pupae of the elm leaf beetle (*Galerucella xanthomelaena* Schr.) that had been collected in eight New England towns were kept under observation by J. V. Schaffner, Jr., and C. L. Griswold for possible emergence of parasites. Adults of a species of Tetrastichus, which C. F. W. Muesebeck later stated represented a new species, issued from collections made in Woburn, Waltham, and Danvers, Mass.; Stratham, N. H.; Newport, R. I.; and Southington, Conn. Judging by the emergence of parasites from these lots, it seemed that only prepupae and pupae of the beetle were attacked. P. A. Berry, who began studying the biology of the species, secured a few records regarding the percentage of pupae killed in the field. Forty-seven per cent of 400 pupae collected in Woburn, Mass., were parasitized, while 80 pupae taken in North Woodbury, Conn., and 50 taken in Washington, D. C., were parasitized to the extent of 42.5 per cent and 10 per cent, respectively.

On August 17, 1932, C. E. Hood collected 100 pupae of the imported willow leaf beetle (*Plagiodera versicolora* Laich.) at Dracut, Mass. Sixty-nine were later found to be parasitized by a species that Mr. Muesebeck has identified as *Schizonotus sieboldi* Ratz., a European species quite possibly introduced with Plagiodera or some closely allied chrysomelid. Eighty-four of another collection of 100 pupae made in Milton, Mass., on September 14 were also parasitized, but Schizonotus adults issued from only 39. In the remaining 45 pupae the Schizonotus had been attacked by hyperparasites.

T. H. JONES, *U. S. Bureau of Entomology*

Decay of Apple Tissue in Storage Associated with Cherry Case Bearer Injury. The Cherry Case Bearer, *Coleophora pruniella* Clem., is primarily a foliage feeder on both cherries and apples. However, the encased larvae commonly do a limited amount of feeding on the fruit of both host plants, especially in the later instars. Likewise, many eggs are deposited on growing apples by the adult moths. It is not uncommon to find two dozen or more eggs on as ingle apple in infested areas of Wisconsin.

Case bearer larvae, upon hatching, emerge from the under sides of the eggs, which are broadly attached to the leaf or apple surface. Thus, on foliage, the newly-hatched larvae get between the upper and lower leaf surfaces and start feeding without being openly exposed at any time. Hatching of the eggs which are deposited on apple fruit occurs in the same way. The tiny larvae may puncture the cuticle, but none of them appear to develop to maturity, as apple tissue is not their normal food and they are usually unable to reach and enter the leaves.

Orchardists have observed that decayed areas appear in apples so infested when they are placed in storage. In the fall of 1932, the writers collected 18 samples of

apples bearing case bearer eggs, which represented several varieties collected from a number of orchards. Each of these samples was divided into three lots for storage in three different environments. It was found that small areas of decay appeared under many of the eggs under all conditions of storage. Decay does not appear under all eggs on fruit, as some of them do not hatch. It was also found that a rot usually occurs around the small feeding areas of the older larvae upon the apple fruit. The most susceptible varieties observed appeared to be Snow and Northwestern Greening.

It is not known whether these larvae introduce the rot-producing organism or organisms directly, or whether they only produce wounds which permit the entrance of secondary organisms. This problem is being further investigated at this Station.

C. L. FLUKE and J. H. LILLY, *University of Wisconsin*

The Species of Eumerus on Long Island. During the last few years it has generally been believed that the species *Eumerus strigatus* Fall. included all of the flies generally referred to as the lesser bulb fly. However, Hodson (Bul. Ent. Res. London 17, pt. 4, 1927) showed that two species, *E. strigatus* Fall. and *E. tuberculatus* Rond., were involved and that the latter was the more prevalent of the two in Holland and various parts of England.

The work of L. M. Smith (Pan-Pac. Ent. 4: 139. 1928) revealed still another species, *E. narcissi* Smith. Smith described only the male of this species, but F. R. Cole later (1929) described the female and redescribed the male in an unpublished report. Randall Latta and F. R. Cole, in another unpublished manuscript (1930), gave extensive descriptions of all three species, with plates illustrating some of the points upon which the classification is based.

This led to a check-up of the pinned specimens on hand at the laboratory at Babylon, which represented field collections for the years 1929, 1930, 1931, and 1932. Field specimens were collected with an insect net at various times of the day, throughout the season. In Table 1 the relative abundance of the two species as deduced from this check-up is shown.

TABLE 1. EUMERUS SPP. ON LONG ISLAND, NEW YORK

Field collection

Species of Eumerus	1929		1930		1931		1932		Total	
	No.	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*
Tuberculatus..	342	94.5	160	95.2	103	97.2	40	100	645	95.41
Strigatus......	20	5.5	8	4.8	3	2.8	0	0.0	31	4.59

During 1931 and 1932 closer observations were made to determine which species was most prevalent not only in the field but also in various other habitats. Collections were therefore made periodically, throughout the active season of the adult bulb fly, in the following places:

(1) In the field.
(2) In a greenhouse where bulbs from various sources were forced.
(3) From a so-called "dump heap" which is a place where growers dispose of all decayed and undesired bulb materials. These heaps are sometimes left uncovered, thereby producing ideal conditions for the rearing of many kinds of scavengers.
(4) From a stock cage, which is a large wire cage placed outside of the laboratory where all available fly-infested material is placed so as to have adult flies for experimental purposes during the following season.

The collections from these sources, including the field material, gave the following:

TABLE 2. EUMERUS SPP. FROM OTHER HABITATS

Season of 1931

Species of Eumerus	Field No.	Field Per cent	Greenhouse No.	Greenhouse Per cent	Dump heap No.	Dump heap Per cent	Stock cage No.	Stock cage Per cent
Tuberculatus	103	97.2	41	97.6	112	89.6	1,293	99.2
Strigatus.........	3	2.8	1	2.4	13	10.4	10	0.8
Season of 1932								
Tuberculatus ..	46	100.0	266	100.0	390	99.2+	680	99.85
Strigatus....... ..	0	0.0	0	0.0	3	0.8—	1	0.15

From this study and according to Table 2 *Eumerus tuberculatus* Rond. was found to be the most common species under all conditions, which verifies the work of Hodson. The percentage of *E. strigatus* Fall. was found to be considerably higher at the bulb dump heap, when compared with other habitats. This seems to suggest that this species is more of a scavenger than the others.

It will also be seen from Table 1 that during 1929 the percentage of *E. strigatus* was 5.5, whereas in 1930 it was 4.8; in 1931, 2.8; and in 1932, 0.0; which shows a general decrease of this particular species.

Prior to these studies *E. narcissi* Smith was reported only from California and Oregon. In the spring of 1931, however, one male and one female were found in a greenhouse on Long Island where narcissus had been forced. These were very likely brought from the West Coast with bulb material. Evidently this species has not as yet become established on Long Island.

The writers wish to acknowledge the aid of Dr. F. R. Cole, of the Bureau of Entomology, who furnished considerable material, including paratypes of *E. narcissi*, for comparison.

F. S. BLANTON and F. J. SPRUIJT, *Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology, Babylon, N. Y.*

A Leaf Miner Attacking the Cultivated Onion.[1] During the course of some investigations of insects affecting the cultivated onion, the writers in 1930 found a few plants at Pleasant Valley, Iowa, whose foliage bore typical leaf-miner injury. Examination of the infested plants proved the mines to contain dipterous larvae and, since there appeared to be no record of an onion leaf miner in the literature of American entomology, efforts were made to carry these larvae to maturity. These efforts, however, proved unsuccessful, as nothing but small parasitic hymenoptera was obtained from the leaves caged that season.

In 1932 an attempt again was made to learn the identity of this culprit. This year the mines were present in much greater numbers, and adult flies were easily obtained. Specimens of these cage-reared flies have been determined by Dr. S. W. Frost as *Agromyza pusilla* Meigen, a widely distributed species that is closely related to the two diptera (*Phytomyza atricornis* Meigen and *Dizygomyza cepae* Hering) that heretofore have been recorded as mining the leaves of *Allium* in Europe.

Field records taken in the onion producing district at Pleasant Valley, Iowa, during the past season show that the mines of *A. pusilla* were present in small numbers on May 17. Five weeks later an estimate, based on counts in plats chosen at random over a large area, placed the number of leaf-miner tunnels present at around 600,000

[1]Journal Paper No. B100 of the Iowa Agricultural Experiment Station, Ames, Iowa, Project No. 135.

per acre. In as much as evidences of a tunnel persist more or less throughout the life of an affected leaf, there is a gradual accumulation of visible injury, and so perhaps not more than one-half of the above number of tunnels contained larvae at any one time. All fields in the Pleasant Valley district were infested, but as was to be expected, the density of miner population varied somewhat in different fields and even in different areas in the same field. Even though the onion has not heretofore been included in the long list of plants known to be attacked by the serpentine leaf miner it seems to be one of the most preferred hosts in this area, for the insects and their mines were much more abundant in onion fields than in surrounding fields containing other plants that also are known to serve as hosts.

In the onion leaf, as in most of the other plants attacked by *A. pusilla*, the mine constructed usually is of the typical serpentine type. The course of a feeding larva rarely is in a continued straight longitudinal direction, the mine practically always more or less completely encircling the onion leaf. Larvae seem to be present in greatest numbers in the younger plants and in the more succulent parts of the older plants, a condition which may result partially from the greater ease with which the female punctures this relatively more tender foliage for feeding and oviposition. In unusually heavily infested areas individual leaves containing a dozen or more mines each can often be found, and in cases of such unusual abundance leaves sometimes contain mines caused by larvae of different broods.

The eggs of *A. pusilla* are placed beneath the epidermis of the onion leaf, the female often feeding on the juices that issue from recently cut egg-niches. The egg stage lasts for a period of from 3 to 5 days and the larval stage from 5 to 7 days. When a larva completes its growth it ordinarily leaves the mine and falls to the ground to seek cover, usually a crack or fissure in the soil, where pupation may occur; at times, however, pupation takes place in the larval mines in the leaves. From 8 to 12 days are required for transformation. Thus, on onion, the development from egg to adult occurs in about three weeks. There are several generations each year, the insect rapidly building up a large population so that late in the season its larval tunnels are very numerous. Nevertheless, from what we know of its injury, it can in no wise be considered as of more than minor importance.

When breeding on onion *A. pusilla* is subject to heavy parasitism, the percentage of parasitism increasing progressively with the season so that the preponderance of insects emerging from infested leaves collected late in the fall are hymenopterous parasites.

H. M. HARRIS and H. D. TATE, *Ames, Iowa*

Note on the Use of Microorganisms for the Production of Odors Attractive to the Dried Fruit Beetle. The possibility of the use of various microorganisms in the trapping of the dried fruit beetle, *Carpophilus hemipterus* (L.), family *Nitidulidae*, and other related forms occurred to the writer while assisting in a field study on the West Coast of various problems connected with food control work. The insects in question are small beetles which cause considerable damage to the fig crop of California, not only by their presence in the fig but also by their transmission of fig diseases. Simmons, Reed and McGregor[1] reported in 1931 on the use of traps for the control of these insects. In their work, slowly fermenting peaches placed in fairly large (10 inch in diameter), specially constructed traps, were used.

[1]1931. Simmons, Perez, Reed, W. D., and McGregor, E. A. Fig Insects in California. U. S. Dept. Agr. Circ. No. 157.

In the experiments performed in testing the possibilities of the controlled use of microorganisms in baiting, small (5 cm x 7 cm) wide-mouthed bottles were used, each fitted with an inverted paper cone, with the opening in the cone about the size of the eye of a fig.

Several types of mold and yeast, grown upon waste dried fruit, were used as bait. The cull fruit was soaked and cooked to the consistency of gruel and then placed in petri dishes previously boiled in water. Due to the limited time available, only a few preliminary experiments could be performed and the majority of these were of value chiefly in indicating precautions to be exercised in future experimentation. As an example of the possibilities present in this work the following description of the first experiment is given.

The following six organisms were used: *Botrytis* sp., *Cladosporium* sp., *Rhizopus* sp., *Fusarium* sp., *Aspergillus niger*, and yeast sp. A single inoculation of each of these was made in two types of media, namely, cooked dried figs and cooked dried peaches. At the end of five days the contents of the twelve plates were transferred to the small, wide-mouthed bottles, filling each about one-third full. These traps were set out at Round Mountain, east of Fresno, California in a Black Mission fig orchard. Six traps of one medium were placed around the base of one tree about three feet from the trunk; while the remaining six were set under the next tree in the row. Each bottle was sunk to the neck in the soil to minimize the effect of the hot sun on the culture. After three days the traps were taken to the laboratory and examined. The predominant insects captured were members of the Nitidulidae family. Their numbers were determined by the use of the kerosene procedure previously developed by the writer.[2] The results were as follows:

Organism	Number of beetles per trap		
	Peach medium	Fig medium	Total
Yeast	205	284	489
Rhizopus	143	88	231
Aspergillus niger	205	91	296
Fusarium	172	181	353
Cladosporium	172	433	605
Botrytis	228	336	564
Totals	1125	1413	2538

The experiment shows that inoculated cull fruits are capable of attracting the beetle in fairly large numbers, even at a time when the ripening figs offer competition.

In a later experiment controls of uninoculated fruit were included and renewed at the end of two days to preclude the effect of contamination. While as high as 70 insects were found in neighboring inoculated traps, no insects were obtained in any of the six controls.

The experiments while incomplete from necessity indicate the possibility of the use of controlled microbiological activity for the production of substances capable of attracting the dried fruit beetle and other related forms. Doubtless other insects would also be attracted to various types of such substances.

The writer is indebted to members of the Bureau of Entomology at Fresno, California for their interest and assistance in the furtherance of this work.

J. D. WILDMAN, *Assistant Microanalyst, Food and Drug Administration, United States Department of Agriculture*

[2]1932. Wildman, J. D. A Simple Method for Separating Certain Insects from Food Products. Science, *75*, 268–269.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL, 1933

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at \$3.00 per page. There is a charge of \$3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings: 1933-34 Boston; 1934-35 Pittsburgh; Summer meetings: 1933 Chicago. 1934 San Francisco.

The 44 years which have elapsed since the organization of the American Association of Economic Entomologists have witnessed marvelous developments. The original membership of 23 has increased to over 1200. The Association has become truly national in character and has extended its influence to all sections of the world. The annual meetings held in different parts of the country bring together the leaders, and in the course of a series of years, nearly the entire membership has an opportunity of making invaluable personal contacts with workers in all parts of the country. The branch meetings carry this still farther. This alone means much, since it promotes a national and international viewpoint hardly attainable in any other manner. The formal meetings are devoted to the presentation and discussion of the latest developments in the respective branches, a phase which no active worker can afford to neglect. It is up-to-date information obtainable in no other way. The annual meetings provide ready means for the consideration and formulation of policies in relation to both investigation and administration.

The Association has exercised a profound and in many cases a determining influence upon the development of such outstanding projects as the control of the gipsy moth, the boll weevil, the European corn borer, the Japanese beetle, the Mexican bean beetle and the Mediterranean fruit fly, to mention just a few of the larger problems in the quarantine

and control field. The National and Regional Plant Boards have been a normal outcome. It will be recalled that a small group of our members served a few years ago in important consultive and administrative positions on the Mediterranean Fruit Fly Board. The Association has rendered material aid by endorsing the introduction of parasites of our more important insect pests. The effiicacy of insecticides and attendant dangers and the possibilities of discovering new materials are subjects constantly coming up for discussion. The establishment of the Journal of Economic Entomology in 1908 and its present development to an annual publication of some 1200 pages has provided a much needed and greatly appreciated medium for the distribution of information to entomologists throughout the world. The exceedingly useful series of Entomological Indexes covering the period from 1905 to 1929 inclusive could not have been published had they not been underwritten by the Association. The Insect Pest Survey, another project endorsed by the Association, has rendered excellent service in the collection and early distribution of seasonal data in relation to insects from all sections of the country.

The size and the diversity of the field is indicated by the three Branches holding large meetings each year, namely the Pacific Slope Branch, the Cotton States Branch and the Eastern States Branch. There is a similar though less formally organized group of Central States entomologists holding meetings of the same general character. The diversity of interests is indicated by the sections of plant quarantine and inspection, of apiculture and of extension, with the possibility later of a section upon insecticides and appliances and one dealing with the immensely important field of medical entomology.

The larger opportunities accruing to members of the Association through the activities of the organization and the undertakings which it has promoted render membership practically imperative for active entomologists and in returns to the members, the benefits are out of all proportion to the relatively very modest dues. The provincialism of earlier days has passed. A scientist must know what is going on in his specialty. This is true of entomologists as well as others. The Association and its activities have welded the economic entomologists of America into a progressive, sympathetic group primarily interested in the development of the science as a whole.

Current News Notes

Dr. R. R. Parker, in Charge of the Rocky Mountain Spotted Fever Laboratory at Hamilton, recently returned from a trip, the itinerary of which included Washington, D. C., New York and Boston, in connection with recent developments in the study of Rocky Mountain Spotted Fever and particularly regarding equipment on the new unit, work on which is to be started April 1.

The sixty-ninth Annual Meeting of the Entomological Society of Ontario was held in the Confederation Building, Ottawa, on December 1 and 2. The meetings were presided over by the President, Dr. W. H. Brittain and the Vice-President, Mr. W. A. Ross, and were well attended. Many excellent papers were presented and discussed, and a special public address entitled "Insects in Relation to Animal and Human Diseases" was delivered by Dr. Robt. Matheson, of Cornell University, on the evening of Dec. 1, in the auditorium of the National Museum. The meetings were concluded by a most enjoyable "Smoker" in the Standish Hall Hotel, Hull, Que.

Horticultural Inspection Notes

The Federal plant quarantine issued in 1929 to prevent the spread of the phony peach disease was revoked effective March 1.

Seasonal transit inspection work has been started at Omaha, Nebraska, and Council Bluffs, Iowa, with Dr. H. L. Dozier in charge.

Space in the new post office building in Chicago will be occupied after April 16 by the transit inspectors working in that city.

Mr. W. R. Shinn formerly stationed at the port of Bellingham, Washington, was transferred to Ysleta, Texas, on February 18, 1933.

After July 1, the address of the Japanese beetle and European corn borer field headquarters of the Bureau of Plant Quarantine will be 2101 North Sixth Street, Harrisburg, Pa.

Mr. E. R. Sasscer visited the Florida ports during the latter part of February for the purpose of conferring with collaborators stationed at those ports on various plant quarantine problems.

A new quarantine relating to the alfalfa weevil issued by the State of Arizona effective on February 1, 1933 places no restrictions on such articles as nursery stock, vegetables (except potatoes), household goods and grain which were restricted under the former quarantine of that State.

The Federal quarantine on account of the pink bollworm was amended effective February 28 to release from restriction six entire counties in Texas and the formerly restricted portion of a seventh county. No pink bollworm infestation has been found in any part of this area since the crop season of 1931.

The State of Pennsylvania has issued a quarantine (No. 24) effective March 15, 1933, relating to the gipsy moth in that State. The movement of host plants and products which might carry the insect is from parts of Luzerne and Lackawanna counties to or through outside points.

Data concerning the narcissus plantings inspected during the calendar year 1932 under the Federal quarantine for the prevention of the spread of bulb pests were released during February as BPQ-349. The number of narcissus bulbs inspected during the year totaled 302,325,265, a reduction of over 70,000,000 bulbs from the previous year.

Following the revocation of the Federal quarantine relating to the phony peach disease, the Georgia State Entomologist issued a revision of Regulation 46. Federal certification of host plants of the disease shipped from the infested areas is required. The new regulation applies to the entire States of Alabama, Arkansas, Florida, Louisiana, Mississippi, South Carolina and Texas and to certain counties in Illinois, Missouri, North Carolina, Oklahoma, and Tennessee.

The ninth annual meeting of the Central Plant Board was held in St. Louis, Mo., on March 1. Messrs. Strong, Worthley, and Corliss, of the Bureau of Plant Quarantine attended and discussed problems relating to Federal plant quarantines. A meeting of the National Plant Board was held at St. Louis during the same week, as well as a special conference concerning possible State quarantines as to the phony peach disease.

The establishing of a Federal service to inspect and certify host plants of the European corn borer has led to the quarantine modification or administrative acceptance by all except one of the ten States which had placed embargoes on the entry of such plants following the revocation of Federal quarantine No. 43. The Wyoming embargo remains in effect. A summary of the corn borer regulations of all the various States has been prepared in the Federal Bureau of Plant Quarantine (BPQ-346, as revised March 16, 1933).

The Washington State Department of Agriculture on January 17, 1933, issued a new quarantine relating to the alfalfa weevil. Nursery stock is not restricted under the present regulations and the area involved does not include Scotts Bluff County, Nebr., and applies to only certain parts of the counties of Lassen, Plumas, and Sierra, in California. The quarantine applies to the entire States of Idaho, Utah, and Wyoming, and certain counties in Colorado, Nevada, and Oregon, as well as parts of the three California counties named.

The Connecticut State quarantine concerning the Asiatic beetle, first established on two small areas in New Haven and West Haven in 1926, was revoked March 1. This insect was found to be present in Bridgeport, Greenwich, Hamden and Waterbury as well as at several points in New Haven and West Haven outside the quarantined area. On account of the present financial conditions and the cost of enforcing the quarantine regulations over a much larger area it was decided to revoke it.

The California Department of Agriculture has revised the quarantines relating to the sweetpotato weevil and the citrus white fly. The only change in the former quarantine is in the areas under regulation. George County, Miss., the counties of Jefferson and Baldwin, Ala., and the northern portion of the State of Louisiana have been removed from the quarantined area. The counties of Glynn and Camden have been added to the quarantined area in the State of Georgia. The only change in the citrus white fly quarantine is in the addition of all Viburnum species to the list of carriers of the citrus white fly, which must be defoliated as a condition of entry.

"This revision," according to the Chief Quarantine Officer, "is based upon the recent interception of citrus white fly infested Viburnum plants from Alabama."

A synopsis of Federal plant quarantines affecting interstate shipments, in effect March 1, 1933, has been prepared and issued as Circular 33-T by the Federal Bureau of Plant Quarantine in mimeographed form, for inspectors' use. Part I outlines the regulated areas, restricted articles and the nature of the restrictions, as to all domestic plant quarantines affecting the interstate movement of plants. Part II provides a general index to the restricted articles by quarantine numbers. Part III lists the post offices located within regulated areas. The circular is a companion to Miscellaneous Publication No. 80, which gives the State regulations affecting interstate movement. A revision of the latter publication is now in proof, which adds an outline of the nursery inspection and certification regulations of the various States to the synopsis of State quarantine orders which was given in earlier editions of this publication.

The Cedar Rust law of Nebraska under which provision is made for the destruction of red cedar trees in the vicinity of apple orchards without compensation to the owners of the cedars was upheld in Federal court under a recent decree. The case is known as Leroy R. Upton, et al, plaintiffs, vs. Dwight Felton, et al, defendants, No. 395 Equity, in the District Court of the United States for the District of Nebraska, Lincoln Division. The case was submitted to a specially constituted court consisting of W. S. Kenyon, Circuit Judge, A. K. Gardner, Circuit Judge, and T. C. Munger, District Judge. The court decided: "That the production and sale of apples from these apple orchards and other orchards in southeastern Nebraska, is a large and important industry, and the continuance of the apple orchards or of the apple trees situated within two miles of these cedar trees are and will continue to be, endangered, if the cedar trees are permitted to remain and no other method is known for avoiding this danger, except the cutting down of the cedar trees," and decreed that the suit by one of the plaintiffs be dismissed and "that the application of the other plaintiffs and of the interveners for a temporary injunction be denied; that the restraining order heretofore granted in this suit be dissolved."

Errata

On page 1245 of the December, 1932, issue, for 43% read 23%, for 28% read 35% and for 32% read 30% in lines 25, 26 and 27 respectively.

On page 181 of the February issue, line 20 for Ecker read Eckert, also in running title on pages 181, 183, 185 and on page 187 read Eckert for Eckler.

THE ENTOMOLOGICAL SOCIETY OF AMERICA

AND

THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JOINT SUMMER MEETING

Plans have been completed for the holding of a joint summer meeting of these organizations at the Century of Progress Exposition in Chicago. The meeting will be held on June 22 and 23. On both of these days a general program of interest to all biologists will be given under the direction of the American Association for the Advancement of Science.

The general banquet of the Association for the Advancement of Science will be held at the Stevens Hotel on the evening of June 22nd. This banquet is in honor of the distinguished guests of the Association, including several men in the biological field.

On June 23rd there will be an afternoon program of general interest to the members of the Entomological societies, possibly including a talk by Dr. Tillyard on the plant and animal life of Australia and New Zealand.

The general reception of the American Association for the Advancement of Science will probably take place at the Field Museum on Friday evening, June 23rd.

The Committee on local arrangements proposes two special events for entomologists. It is tentatively planned to hold a luncheon for members of the Entomological Society of America, the American Association of Economic Entomologists, and their guests at 12:30 P.M. on Thursday, June 22nd. This luncheon will be followed by a talk by Dr. Tillyard of Australia, probably on fossil insects. This will be followed by a talk by some noted American biologist.

An Entomologists' dinner will be held at the Chicago Woman's Club at 6 o'clock on the evening of the 23rd.

The general headquarters of the American Association for the Advancement of Science will be at the Stevens Hotel.

The following hotels offer room rates at approximately $2.50 and up per person:

Allerton Hotel, 701 N. Michigan Avenue; Congress Hotel and Annex; Harrison Hotel, one-half block off Michigan Boulevard; Morrison Hotel; Sherman Hotel, Randolph Street at Clark Street; Stevens Hotel, Michigan Boulevard, 7th to 8th Street.

The Bismarck Hotel, Randolph at LaSalle Street and the Palmer House offer rates of $3.50 and up.

Members coming with their wives will find excellent accommodations at the Woman's Club, 72 East 11th Street, across the street from the Fair. The rates for a single room are $2.50 and up. Fifty rooms are available.

Numerous auto camps for Fair visitors are provided in and near Chicago. Information regarding the location of these camps and general information in respect to hotels in Chicago may be secured by writing to the Bureau of Information, Chicago Century of Progress, Administration Building, Burnham Park, Chicago, Illinois.

C. L. METCALF
J. J. DAVIS
W. P. FLINT
Committee on Local Arrangements

JOURNAL
OF
ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Vol. 26 | JUNE, 1933 | No. 3

The Proceedings of the Forty-Fifth Annual Meeting American Association of Economic Entomologists

Friday Afternoon, December 30, 1932

THE PRESENT STATUS OF THE GLADIOLUS THRIPS IN THE UNITED STATES

By C. A. Weigel and Floyd F. Smith[1] *Truck Crop and Garden Insects Investigations, Bureau of Entomology, U. S. Department of Agriculture*

Abstract

The present distribution, economic importance, and seasonal history, including overwintering, of this thrips (*Taeniothrips gladioli*) are discussed. Observations on the effectiveness of control measures employed by commercial growers are also presented.

The gladiolus thrips (*Taeniothrips gladioli* M. & S.) has continued to be a serious pest of gladiolus during the past year and has caused severe injury over a considerably greater area than previously reported. Since the flowers are so popular with home gardeners, the destructiveness of this insect has been particularly felt by them, not to mention the huge losses sustained by the commercial growers

According to the present records, based upon specimens received and identified by Dr H Morrison, of the Bureau of Entomology, this thrips is now known to occur in California, Connecticut, Georgia, Indiana, Maine, Maryland, Massachusetts, Michigan, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Virginia and West Virginia. It has also been reported from Florida, Kentucky, Illinois, Missouri and

[1]Through the courtesy of Prof. P. J. Parrott, of the New York State Agricultural Experiment Station, Dr. F. L. Gambrell aided in the surveys made in western New York. Several gladiolus growers, particularly Mrs. Stella M. Antisdale, of the American Gladiolus Society, and Mr. Henry Breuss, of Hamburg, N. Y., have facilitated the gathering of much valuable information pertaining to this pest.

Wisconsin. The insects appear to have been especially abundant and destructive during the past season in the Eastern Atlantic States.

In addition to the gladiolus thrips, the following eleven species and varieties of thrips have been collected on gladiolus during the past season:

Aeolothrips fasciatus Lind.
Chirothrips manicatus Haliday
Frankliniella fusca Hinds
Frankliniella nervosa Uzel
Frankliniella occidentalis Perg.
Frankliniella tritici Fitch
Frankliniella tritici var. *bispinosa* Morgan
Heliothrips femoralis Reuter
Limothrips cerealium Haliday
Sericothrips cingulatus Hinds
Thrips tabaci Lind.

During the early part of the season the tobacco thrips, *F. fusca* Hinds, was very abundant in most gladiolus plantings and caused considerable confusion among the growers. This was due to their inability to distinguish this form and its injury, as well as the others mentioned above, from the gladiolus thrips on this host, as well as on the many other hosts upon which these and other thrips often occurred.

INJURY AND ECONOMIC IMPORTANCE. –The direct injury caused to the foliage and flowers has already been described in a previous article.[2]

The gladiolus thrips, in feeding on the corms during the storage season, disfigure the surface by causing injury to the cells, which is followed by suberization. Their feeding at the base of the corms on areas from which the roots arise causes the death of these rootlets or root buds, and new ones must be formed from the tissue beneath, thus slowing up root development after the corms have been planted. Direct injury to the sprouts also occurs in storage. The combined effect of these injuries is retardation and stunting of growth and the production of smaller flowers. In some instances the corms produced a weak growth which died as the corms rotted. Considering the injury to the foliage, flowers, and corms, the economic importance of this pest can be readily appreciated.

In addition to its importance as a pest to outdoor-grown gladiolus, florists in the District of Columbia, Maryland, and Virginia suffered a complete loss of the flowers from corms forced in the greenhouse, in certain instances from corms which were known to be infested but not treated before planting.

HOSTS.—In addition to the natural infestation on tigerflower (*Tigridia* sp.) Montbretia (*Tritonia* sp.), and the torchlily or pokerplant (*Knip-*

[2]Smith, Floyd F., and Weigel, C. A. Taeniothrips gladioli M. & S., a New Pest of Gladiolus, Jour. Econ. Ent. 25: 312–318, illus. 1932.

hofiia spp.) occurring in the field, as previously recorded,[3] this thrips has been reared on foliage of Japanese iris and on the dormant bulbs of Spanish iris. An occasional adult has also been found on Coreopsis and on other plants that have been previously reported,[3] but breeding was not observed in these instances.

SEASONAL HISTORY. -From the studies thus far conducted it is evident that these thrips are taken into storage when the crop is harvested, continue to feed and breed on the corms throughout the winter, and are taken to the field when the corms are planted. As the young sprouts push their way through the soil the thrips follow and immediately attack the new growth The thrips begin breeding at once and increase in numbers until flowering time, when the population reaches its maximum. They become greatly diminished at the end of the flowering season, whether the flower is cut or is allowed to mature on the plant. A few, however, persist on the plant as long as the foliage remains green. In general practice it is customary to harvest the crop while the foliage is still green and the thrips are still present. While the corms are drying in the field, the thrips have an opportunity to crawl to the corms or are shaken onto them when the tops are cut off, and in this way are taken into storage. Observations thus far indicate that the thrips apparently do not infest the corms in the fall, while they are still in the ground, except when corms are exposed by erosion or cracking of the soil. It has also been observed that where harvesting was delayed until the tops had died completely and left no food for the thrips, the corms were dug and harvested without developing infestation. While this procedure demonstrates the possibility of harvesting the crop without its becoming infested, such a practice has certain drawbacks which would not be acceptable to the growers. The almost necessary commercial practice of digging the crop while the tops are still green and thrips are present is unfortunate, since this is the principal means by which the thrips gain access to the storage from the field.

OVERWINTERING OUT OF DOORS.--Probably the most important point in the development of this insect from the standpoint of control hinges on whether it overwinters successfully out of doors Although some evidence is now available that it does not overwinter in the field in the Northern States, further data are needed definitely to establish this point. The evidence at hand includes the following points: (a) Thrips did not survive in New York State and in Washington, D. C., on caged or uncaged infested tops that were left in the field over winter. (b) They did not survive on corms of infested plants left undug in the ground.

[3]Op. cit.

This point was established by examining corms dug in the spring and by the absence of thrips on the flower crop produced from the undisturbed corms in two fields. This is in marked contrast to the complete loss of flowers during the preceding season. (c) There were no thrips on Japanese and German iris and poker plant in the spring of 1932, although they were present in the fall of 1931, as verified by field and caged material. (d) A thrips-free crop of gladiolus was grown in 1932 in the same or adjacent fields and gardens following effective treatment of the corms from the severely infested crop of 1931. This was definitely demonstrated in 5 cases in New York, in 2 in Ohio, and in 1 in Virginia.

NATURAL ENEMIES.—The predator (*Triphleps*) *Orius insidiosus* (Say) has been found to be associated with practically all infestations of this thrips and appears to have a limiting effect on its abundance. With one possible exception, however, it has not been able to reduce the numbers to a point sufficient to prevent flower injury.

EFFECTIVENESS OF CONTROL MEASURES EMPLOYED BY GROWERS. *Treatment of corms.* Since it is now recognized that the planting of infested corms will result in establishing infestation in the growing crop, the necessity of effective corm treatment to eliminate this source of infestation is evident. On the basis of preliminary recommendations that were presented in the Florists Exchange,[4] commercial growers employed some of these remedies, together with others not suggested, and the results which they obtained have been observed These treatments included the following:

(a) Calcium cyanide. One grower who fumigated his stock failed to control the thrips because he allowed too great an interval between the fumigations. Three other growers obtained good results, except in stocks where the scales were moist, which apparently prevented the proper diffusion of the gas.

(b) Bichloride of mercury. This chemical has not proven entirely effective on unpeeled corms, according to the results obtained by five growers, where the immersion period was from 3 to 7 hours or overnight.

(c) Semesan. One grower successfully eliminated thrips on 10,000 corms that were immersed 17 hours in Semesan solution—1 pound to 50 gallons of water— and obtained similar results on 75,000 corms treated for 7 hours in a solution of 1 pound of Semesan to 10 gallons of water.

(d) Tobacco dust. One grower found that this material was not completely effective where the corms in the trays received a heavy applica-

[4]Weigel, C. A., Smith, Floyd F., and Richardson, Henry H. The Gladiolus Thrips. Florists Exchange 79: 11, 40, 80B, No. 11, March 12, 1932.

tion, since a few living thrips were observed beneath the scales of some corms three months after treatment.

(e) Ethylene dichloride-carbon tetrachloride mixture. Two growers successfully controlled the thrips with this mixture where the proper precautions as to dosage and exposure were observed. One grower who observed these precautions allowed reinfestation of his treated stock to take place because he did not isolate it from the untreated stock, and thus failed to control the thrips. The corms of four growers who employed much larger dosages or longer exposures than recommended were so severely injured that they were practically a complete loss.

(f) Lye solution. One grower immersed his corms, before planting, in a solution containing one pound of sodium hydroxide in 20 gallons of water for a period of 24 hours and failed to control the thrips. Incidentally, he also treated his stock at digging time in a solution containing 1 pound of copper sulphate in 10 gallons of water, followed by one fumigation with calcium cyanide, without the desired results.

(g) Naphthalene flakes. Three growers who fumigated their entire stock with this material before planting obtained complete control of the thrips and grew a normal crop of flowers.

Of the seven corm treatments for thrips control employed by the growers that have been observed, immersion in Semesan, fumigation with the ethylene dichloride-carbon tetrachloride mixture, and fumigation with naphthalene flakes, were completely effective. It now appears that treatment with naphthalene flakes is most suitable to the average grower when effectiveness, economy, and absence of danger of injury to the corms by overdosage are considered.

Treatment of the growing crop. Thus far no definite observations have been made on the effectiveness of sprays and dusts, including combinations with nicotine, Bordeaux mixture, pyrethrum, and derris, applied by commercial growers for the control of this thrips under field conditions. However, information gleaned from correspondence with growers indicates that no entirely successful control was obtained by the methods they used.

Observations in several greenhouses showed that the thrips was not controlled where the florists sprayed twice weekly with a strong solution of free nicotine or pyrethrum extract or where they applied naphthalene flakes to the surface of the soil of the bed in which the plants were being forced.

Summary and Conclusions.—The gladiolus thrips has continued to be a serious pest during 1932 over a larger area than previously reported. Eleven other species of thrips have been collected on gladiolus and

evidently these have often been confused with the gladiolus thrips. In addition to the injury to foliage and flowers, the thrips, by feeding on the stored corms, cause injury to the corm surface, rootlets and sprouts, which results in a retardation of the development of roots and sprouts when the crop is planted. The resulting growth and flowers may be stunted, or, as in severe cases observed, the plants may fail to grow. The thrips has been reared on the foliage of Japanese iris and on the bulbs of Spanish iris.

The thrips is taken into storage at harvest time and breeds in storage until planting time, when it is taken back to the field. It then increases in numbers and injures the foliage and flowers. In cage tests and field observations the thrips failed to overwinter on other host plants out of doors, in piles of gladiolus tops, or on corms in the soil. Further evidence of the non-overwintering of this thrips was observed in 7 cases in which a thrips-free crop was grown in 1932 in the same fields in which the 1931 crop was severely infested, or in adjacent fields.

The predator *Orius insidiosus*, while commonly present in the field, has failed to prevent serious flower injury.

Of the various corm treatments employed by commercial growers, the immersion in Semesan solution, or fumigation either with naphthalene flakes or with the ethylene dichloride-carbon tetrachloride mixture, give complete control. The last-named fumigant caused severe injury when improperly used, that is, when an overdosage or overexposure was employed. Naphthalene flakes appear to be the most suitable corm treatment for use by the average grower.

LIFE-HISTORY STUDIES OF THE GLADIOLUS THRIPS (*TAENIOTHRIPS GLADIOLI* M. & S.)[1]

By Floyd F. Smith and R. H. Nelson, *U. S. Bureau of Entomology, Washington, D. C.*

Abstract

The cages used for life-history studies of the gladiolus thrips on corms and growing plants are described. Data on habits, parthenogenesis, oviposition, and development, at controlled temperatures on stored corms and on plants in the insectary, are given.

Information on the life history and development of the gladiolus thrips is of direct practical value in applying control measures to the stored gladiolus corms, in determining proper temperatures for storing

[1]Order Thysanoptera, family Thripidae.

corms,[2] and in field control. In order to obtain this information detailed studies on the oviposition and development of the thrips were conducted on dormant corms during the 1931–32 storage season, and on the aerial growth during the summer of 1932 in the insectary. The present paper describes the technic used in conducting these studies and presents the data obtained on the life history of this insect under both conditions.

TECHNIC —For life history studies in storage, cormels, removed from their covering, were used as food for the thrips, since they were readily obtained free of infestation,[3] and were of convenient size for making observations They were impaled on the point of a pin thrust through a cotton stopper and placed in a vial (Plate 24) cage for exposure to the ovipositing adults, for incubation of the eggs, for larval development, and for pupation records A round-bottom vial is more desirable for observation than the flat-bottom type shown, but is less convenient in other respects.

For insectary studies the cormels were germinated at a temperature of 90° F. in moist sand and potted into 2½-inch pots. When the sprout reached 2 or 3 inches in height the plant was caged (Plate 24) with a 1 inch by 5 inch open-end vial which was provided with a cloth-covered cotton stopper. The vial was held in position by means of a rubber band and a plant label forced into the soil Disturbed thrips often descend the plant and hide among the soil particles, so white sand was poured over the soil surface in the cage as an aid in locating the insects, particularly the adults. Both types of cages supply the insects with normal plant tissue yet permit thorough examination under the wide-field microscope. To enable the insects to regain the plant tissue if they jumped off, and to supply a favorable feeding place, the vials were always adjusted so that the leaf or cormel rested against the side.

The life-history pairs were transferred daily for obtaining oviposition records. Larvae, hatching from eggs placed in the plant tissue, were transferred to separate cages for rearing to adults. All transfers were made with a camel's-hair brush; the adults without magnification, the other stages under a low-power binocular.

STAGES OF THE INSECT.—The immature stages of the gladiolus thrips in general resemble those of the pear thrips, *Taeniothrips inconsequens* Uzel, in that there are two active larval instars and two pupal instars.[4]

[2]Weigel, C. A., Smith, Floyd F., and Richardson, Henry H. The Gladiolus thrips. Florists Exchange 79: 11, 40, 80B, illus. March 12, 1932.

[3]Smith, Floyd F. The natural protection of gladiolus cormels from thrips' attack. Jour. Econ. Ent. 25: 1110. 1932.

[4]Foster, S. W., and Jones, P. R. The life history and habits of the pear thrips in California. U. S. Dept. Agr. Bul. 173, 52 p., illus. 1915.

However, the gladiolus thrips does not construct a cell of any sort for the pupal stage, even when pupating in the soil. The eggs, placed within the leaf or corm tissue by the ovipositing females, are kidney-shaped, translucent or opaque in appearance, and measure 0.3 mm in length and 0.11 mm. in diameter

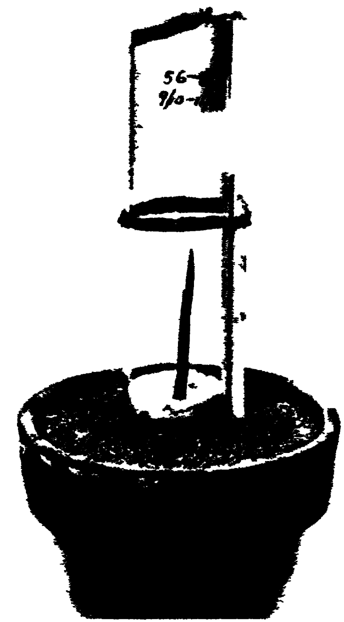
In hatching, the insect within the unbroken chorion forces the fore part of the body outside the plant surface The chorion is then ruptured and the milky-white larva emerges. The newly hatched larva measures about 0 5 mm. in length. Feeding soon begins and the body color changes to a lemon yellow, which is maintained through the larval and pupal stages During the larval stages, however, certain colors, due to ingested chlorophyll from leaves or other coloring material from flowers or corms, are visible through the body wall. This coloring matter taken up with the food is apparently undigestible, as shown by the dried particles of colored fecal matter.

The first two molts are preceded by brief quiescent periods The two stages of the pupa are distinguished by the short wing pads of the first and the long wing pads of the second The insect does not feed in either pupal stage and moves about feebly only when disturbed

In the molting process the caudal end of the body is attached to the leaf or corm surface, and, after splitting the dorsum of the covering anteriorly, the insect pulls itself out of the old skin The process required from 2 to 4 minutes in the many observed cases

At first the adults are milky white but soon become darker and start to feed. They mate and lay eggs on the first or second day The male and female adults are readily distinguished, and the sexes can be recognized in the last pupal stage.

Life History and Development in Storage. During the winter of 1931-32 four series of tests on the oviposition rate of adults and on the periods of incubation and development of the thrips were conducted at constant temperatures in an air-conditioning cabinet at 50°, 60°, 80°, and 90° F. In addition a series was conducted in the greenhouse laboratory at approximately 70° F. The results on the various phases of the life history of 29 females and 20 males in the 70° series are summarized in Table 1 These 29 females, and one other which escaped after having laid 167 eggs, deposited a total of 3,566 eggs. Usually only one or two eggs are laid on each of the first few days of adult life, but the rate soon increases. The greatest number of eggs laid in one day by one female was 18. In this series 50.1 per cent or 1,788 of the eggs were laid during the first two weeks of adult life, and 87.2 per cent or 3,111 eggs were laid by the end of the fourth week, although surviving females laid eggs dur-



[illegible] studies left on cormels right on growing plant

ing the ninth week. In comparing the daily oviposition rates of individuals during the first two weeks of adult life, 0.41 egg per day were laid at 50° F., 1.38 eggs at 60°, 4.11 eggs at 70°, and 7 19 eggs at 80°. The adults held at 90° were adversely affected by the high temperature and soon died without laying more than a few eggs. These studies indicate that the optimum temperature for most rapid reproduction in storage is probably near 80° and that 50° and 90° represent the approximate extremes for oviposition

The data on incubation and development of the thrips on cormels at the various temperatures are summarized in section A of Table 2. Eggs hatched at the 60° to 80° temperature ranges, but none of the hundreds of eggs in cormels held for 4 or 5 weeks at 50° hatched at that temperature or when returned to room temperatures after such exposure At a temperature of 90°F. and 50 per cent relative humidity no larvae hatched, at 90° F and 100 per cent relative humidity only 7 larvae hatched from 200 eggs It is apparent that 50° and 90° represent approximate extremes of temperatures for hatching from corm tissue

In 13 laboratory tests to determine the effect of cold on the eggs it was found that larvae hatched from eggs in corms which were returned to room temperature after exposure of 4 days or less at 33°F., but that none hatched from corms which had been chilled for 7 to 22 days. The minimum periods of exposure required for preventing the hatching of eggs at various low temperatures, 50° F or below, are now under investigation Whether the effect of high and low temperatures alone, or its combination with the suberization of the corm tissue, prevents hatching is yet to be determined Of practical importance is the apparent prevention of egg hatching at 50° F or below, and this fact should lead the gladiolus grower to store his stock at a low temperature.

Larvae and pupae completed their stages at temperatures ranging from 50° to 90° F , but the mortality was high at the two extremes. At 50° F. 23 per cent of 200 larvae were reared. At 90° F. and 50 per cent relative humidity none of 207 larvae or of 200 pupae were reared. At the same temperature and 100 per cent relative humidity only 1 of 86 larvae and 11 of 65 pupae were reared Attempts to rear complete generations at 50° and 90° failed. Although no individuals were reared from egg to adult at 60° F. because the test was closed for other work, it would doubtless have been possible to do so. A generation would require about 31 days at 60° F., based on the length of the developmental stages. Average periods of 19 and 10.6 days were required at 70° and 80°, respectively, according to actual records. The studies indicate that the most rapid reproduction and development take place at or near 80°F. in storage.

Life History in the Insectary.—The detailed life-history studies conducted during 1932 were begun June 9 and terminated November 1. The information relative to 17 females and 15 males is summarized in Table 1. Three other females, included in the table under preoviposition period, were lost or accidentally killed, thus terminating the completion of the other records on their lives. The 17 females, which deposited a total of 2,226 eggs, laid 1,198 or 53.8 per cent of the eggs during the first 10 days of adult life and 2,141 or 96.18 per cent of them during the first four weeks, although surviving females laid a few eggs during the seventh week. The daily oviposition of each of these females during the first two weeks of adult life averaged 6.54 eggs, and the greatest number laid in one day by one female was 20.

Table 1. Summary of Data on Life History Studies of Adults of *Taeniothrips gladioli* M. & S on Stored Corms at Approximately 70° F. and in an Insectary at Seasonal Temperatures; Washington, D. C., 1931 1932

	Individuals observed		Maximum		Minimum		Average	
	Insectary No.	Storage No.	Insectary Days	Storage Days	Insectary Days	Storage Days	Insectary Days	Storage Days
Preoviposition period	20	30	3	15	0	0	0.65	2.8
Oviposition period	17	29	48	63	12	7	26.65	30.58
Postoviposition period	17	29	22	39	0	0	5.41	8.4
Age of females at death.	17	29	58	76	13	19	32.82	42
Age of males at death	15	20	49	64	13	10	26.74	42.5
			No.	No.	No.	No.	No.	No.
Eggs laid per female	17	29	202	204	57	7	130.94	117.2

Data on the period of incubation, of the larval and pupal stages, and of the elapsed time from egg to adult are summarized in Table 2, section B. All of the 268 recorded individuals entered the soil to pupate except 25 which pupated on the sides of cages. The thrips pupating in the soil spent from 1 to 5 days longer in the pupal stage than did those pupating above ground in the same cages. This is doubtless due to the lower temperature prevailing in the soil and accounts for the greater length of the pupal stage under insectary conditions. In the studies on corms (Table 2, section A) where all stages developed under the same conditions, the pupal stage was approximately the same or slightly shorter than the larval period.

During the period of June 10 to September 6, six generations were reared to adults at an average rate of one generation in two weeks. Thrips were observed breeding on foliage of gladiolus in gardens as early as May 5, 1932, and as late as December 12, 1931. Based on these observations it seems possible that additional generations could develop

in the spring and in the fall if green foliage were present on the growing gladiolus crop.

TABLE 2. DEVELOPMENT OF *Taeniothrips gladioli* M. & S ON GLADIOLUS AT WASHINGTON, D. C., 1931–1932

Section A—On dormant corms at temperatures indicated during the winter of 1931-1932

Stage of insect	Temperature °F.	Individuals observed Number	Period of Development Maximum Days	Minimum Days	Average Days
	60	153	15	8	9.97
Egg.	70	517	9	5	6.3
	80	271	5	3	3.6
	90	7	6	3	4.7
	50	46	33	22	27.08
	60	49	14	9	11.3
Larva	70	428	9	5	6.92
	80	159	4	3	3.44
	90	1	-	—	4
	50	26	22	17	19.7
	60	33	14	8	10.3
Pupa	70	319	10	4	6.1
	80	73	5	3	3.7
	90	11	4	3	3.63
Egg to adult	70	311	24	16	19
	80	30	12	9	10.6
Section B--In insectary during the season of 1932 at seasonally varying temperatures					
Egg		2,090	8	3	4.66
Larva.		268	7	2	3.78
Pupa		268	14	3	6.61
Egg to adult		418	25	11	15.5

Since the development of immature stages, the longevity and oviposition of adults, and other points in the life history are so similar at an approximate temperature of 70° to 80° F. on stored corms and on foliage, it appears that the insect thrives equally well on the two types of food. It also appears that development depending upon the temperature, may be continuous throughout the year on gladiolus foliage or on the stored corms and that there is no definite seasonal period of hibernation.

PARTHENOGENESIS AND MATING.—Foster and Jones[5] reported that the pear thrips produced only females without fertilization (thelyotoky) and that males were not found in California. The gladiolus thrips normally mates and the offspring include both sexes, although only 32.5 per cent of the 874 reared offspring of mated females were males. In 15 cases where females were isolated without mating, and their offspring reared to adult, all were males (arrhenotoky). In several tests the

[5]Op. cit., p. 38.

unfertilized females were mated with their own offspring and the eggs laid subsequent to this mating produced both males and females. One female could thus initiate an infestation.

Because of the apparently great attraction between the sexes, and the polygamous nature of the males, it is believed that unmated females are normally rare, even though females are relatively more abundant than males. The mating act, in many observed cases, required $1\frac{1}{4}$ to 3 minutes. One male has been observed to mate with as many as eight females in one day, but a female which has once mated will apparently refuse to mate again during her life. Females are usually mated the first day after emergence, but one isolated virgin female was mated when 55 days old, and two female offspring were reared from eggs subsequently laid.

HABITS. — *Thigmotropism vs. phototropism* The studies have shown that this insect is positively thigmotropic, especially in the larval stage, but also to a less marked extent in the adult stage. The larvae congregate on the side of the cormel or leaf which lies against the side of the cage, where they feed until forced to go to other areas for want of food In this narrow space the larvae, while feeding, frequently elevate the antennae until they touch the side of the cage above them If the cormel or leaf is slowly moved away from the side of the cage until the insects are unable to reach the latter by elevating their antennae, they become disturbed and start running about They will again congregate as before if the narrow space is restored The insects behave in this manner whether in darkness or full sunlight, and a change in light intensity apparently does not disturb them Larvae and adults, tested with regard to their reaction toward light by placing them on sheets of paper or on glass plates, with light coming from one direction, show no response either positively or negatively by direction of movement. On the basis of these observations the authors, therefore, believe that the large proportion of the insects, the larvae especially, remain in the leaf sheaths and other secluded places, until the food supply is exhausted, because of their positively thigmotropic reaction instead of the negative response to light. The sudden appearance of the insects on the foliage in the field may be correlated with the exhaustion of the food supply in the sheaths and the consequent moving of the insects to the exposed surfaces.

The response to heat above certain temperatures may be a factor in the daily behavior of the insects in the field.

Biting habits. Larvae and adults, crawling about on the authors' bare arms have sometimes produced pain by piercing the skin with their mouth parts.

Quarrelsome habits of larvae. Larvae usually feed quietly in numbers close beside one another, but frequently show quarrelsome traits. One larva may crawl partly upon another larva or pupa and then evidently inflict a pain-producing thrust with its mouth parts. The victim, if a larva, either returns the punishment or moves quickly away; if a pupa, it escapes by feeble effort. It is believed that the insect's habit of isolating itself from other larvae before pupating, and thus avoiding disturbance during the quiescent period, may be correlated with this quarrelsome habit In the field this habit often carries the insect to the soil for pupation.

Sluggish nature and migration. In comparison with the activity of other thrips, such as *Frankliniella fusca* Hinds and *F. tritici* (Fitch), the gladiolus thrips is relatively sluggish At room temperatures adults can be transferred by means of a camel's-hair brush without disturbing them more than to cause an occasional one to jump. At 80° F. or slightly above they become much more active and will jump and fly short distances Their relative inactivity at ordinary temperatures is probably correlated with the small amount of migration occurring in the field before flowering time, after which they are forced to move in search of food.

In feeding on the corm, foliage, or flower parts, the thrips remove the contents of the surface cells, and such areas furnish no further food because the insects are unable to reach the cells beneath In addition, suberization follows the feeding on the corms and this thickening of the area prevents further feeding.

SUMMARY.—The methods used in life-history studies on dormant cormels and in the insectary, and the egg and the two larval and two pupal stages, are briefly described.

The studies showed that 50° and 90° F. represent the approximate extremes of temperature for development, since no eggs hatched at either temperature, except a few at 90° F. and 100 per cent relative humidity. Eggs in corms exposed for 7 days or longer to a temperature of 33° F. failed to hatch. Larvae and pupae which developed slowly at 50° F. required average periods of 27 and 19 days, respectively, for development. At 60°, 70°, and 80° the insect developed normally but at accelerated rates with each higher temperature, since incubation required average periods of 10, 6.3, and 3.6 days; larval development 11.3, 6.9, and 3.4 days; pupal stages 10.3, 6.1, and 3.7 days; and the total development 31, 19, and 10.6 days, respectively.

Six generations, each requiring approximately 2 weeks, were reared in the insectary between June 10 and Sept. 6. Additional generations may

develop out of doors during one season in this area and breeding may be continuous on gladiolus foliage or corms at favorable temperatures. There is no evidence of seasonal hibernation. Adults lived as long as 76 days, but the average for both sexes ranged from 26 to 32 days in the insectary and 42 days at 70° F. in storage. A maximum of 204 eggs were laid by 1 female, but the averages were 117 and 130, respectively, in storage and insectary. Mating normally takes place and both sexes are represented among the offspring, but unmated females produce only male offspring.

The habits of the larvae of feeding in the leaf sheaths instead of on the exposed surface seem to be due to a positive thigmotropism rather than to negative phototropism. Larvae are often quarrelsome and evidently thrust others with their mouth parts, and this habit may be correlated with the isolation of the insects in the pupal stage. This thrips is relatively inactive at 70° F. or below and migrates very little in the field at this temperature.

PRELIMINARY REPORT ON THE CONTROL OF THE GLADIOLUS THRIPS ON CORMS IN STORAGE

By Floyd F. Smith and Henry H. Richardson,[1] *Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture*

Abstract

Results are given on tests with various corm treatments, including heat, fumigants, insecticidal and fungicidal dips, dusts, and smudges, with reference to the mortality of the gladiolus thrips (*Taeniothrips gladioli*) and the effect on the corms and succeeding growth.

An important source of field infestation of the gladiolus thrips, *Taeniothrips gladioli* M. & S., will be removed by an effective control measure applied to the corms before planting. The laboratory experiments with various materials as possible control measures, conducted during the winter of 1931–32, formed a basis for the preliminary recommendations for control made to the growers in the spring of 1932[2]. During this period 107 tests upon 8,741 gladiolus corms of five varieties and one mixture of varieties were conducted. The preliminary results herein reported should be considered primarily for the effectiveness

[1]The following New York gladiolus growers have aided in this investigation by their contribution of several types of gladiolus corms: Henry Breuss, Hamburg; W. W. Euler, Honeoye Falls; John W. Scott and John Charlton, Rochester.

[2]Weigel, C. A., Smith, Floyd F., and Richardson, Henry H. The Gladiolus Thrips. Florists' Exchange, Vol. 79 (No. 11), pp. 11, 40, 80B, March 12, 1932.

against the thrips and secondarily for the effect on the corm and the subsequent growth. The latter phase requires further study before the status of each treatment is definitely established.

METHODS.—The corms were well cured and the scales were dry at the time of treatment The scales were left on the corms in all tests, because, except for the small grower, it is considered impractical to remove the scales before making the treatment Infested corms were mixed with uninfested ones and stored in trays for from one to three weeks, when they would become infested. The tests with fumigants were made in a 200 cubic foot fumigation box at a temperature of 60° F , except as otherwise indicated. Fumigations with naphthalene flakes and insecticidal dusts were conducted by placing the material among the corms in an open tray or in a tied paper bag

The insecticidal and fungicidal dips were used at a temperature of approximately 70°F The tests with vapor heat were made in an air-conditioning cabinet and those with hot water were made in a thermostatically controlled treating tank as used for treatment of narcissus. The lots of corms which were given the treatment with one of the dips or with hot water were placed in thrips-tight cloth sacks before treatment and were then left in these sacks until dry enough for examination. Following treatment, each lot, after being placed in a tough paper bag and the top folded tightly to prevent entrance or exit of thrips, was stored in a cellar at a temperature of approximately 60° F. All of the treated stock was planted in plots on May 26, and records were made on the growth, flowering, and harvested crop of corms

In recording the effectiveness of each treatment the old dried and broken thrips were discarded and only the recently killed insects were counted. This largely eliminated the possibility of counting thrips that died from starvation or old age. Although the dead and living larvae, pupae, and adults were recorded separately, the results are included in one figure in the present paper, since the various stages of the insect, except the egg, did not appear to differ greatly in susceptibility to treatment. Where the treatment was ineffective no extended counts were made.

The materials and treatments tested include the following fumigants, insecticidal dusts, insecticidal and fungicidal dips, and treatments by heat:

Calcium cyanide, a granular form containing 40 to 50 per cent calcium cyanide.
Ethylene dichloride-carbon tetrachloride mixture containing these chemicals in a ratio of 3 to 1 by volume.
Ethylene oxide.

Naphthalene flakes used at the rate of 1 ounce to 100 corms.

Pyrethrum smudge. A mixture of 12.5 per cent sodium nitrate and 87.5 per cent pyrethrum powder containing 1 per cent pyrethrins was burned in the chamber at the rate of one-half pound per 1,000 cubic feet.

Nicotine dust containing 1 per cent nicotine as nicotine sulfate in hydrated lime.

Pyrethrum dust containing 1 per cent pyrethrins.

Soap solution. A potassium-cocoanut oil soap was used.

Nicotine and soap solution containing nicotine sulfate 1-600 and 0.5 per cent of the above soap.

Pyrethrum extract and soap solution containing pyrethrins 1–5,000 and 0.5 per cent of the above soap.

Glue sizing in water.

Lye solution consisting of 1 pound of potassium hydroxide in 25 gallons of water.

Corrosive sublimate, 1 part mercuric chloride in 1,000 parts of water.

Calomel, 1 part of mercurous chloride suspended in 40 parts of water.

Ceresan, 1 part of this material, (containing 1.6 per cent ethyl mercury chloride) suspended in 200 parts of water.

Semesan, 1 part of this material (containing 30 per cent hydroxymercurichlorophenol) in 50 parts of water.

Carbolic acid, stock solution containing 88 per cent phenol, diluted as indicated.

Vapor heat.

Hot-water immersion.

The results of the tests are given in the table and in the discussion which follow.

TABLE 1. MORTALITY OF *Taeniothrips gladioli* ON DORMANT CORMS RESULTING FROM VARIOUS TREATMENTS OF THE CORMS

Treatment	Duration of treatment	Tests	Corms treated		Total insects examined	Ave. insects killed in tests
	Hours	*Number*	*Number*	*Variety*[1]	*Number*	*Per cent*
Calcium cyanide						
20 ounces[2]	1	2	50	c, f	520	100.0
5 ounces[2]	3	3	96	c, d, f	269	100.0
2½ ounces[2]	3	3	70	c, d, f	220	100.0
1¼ ounces[2]	3	7	275	a, c, f	1,694	99.9
½ ounce[2]	3	3	75	a	403	95.0
Ethylene dichloride-carbon tetrachloride mixture						
14 pounds[2]	4	1	25	f	104	92.3
14 pounds[2]	8	1	25	f	110	100.0
14 pounds[2]	12	1	25	f	151	100.0
14 pounds[2]	24	2	50	f	169	100.0
10.7 pounds[2]	24	1	40	f	60	100.0
Ethylene oxide						
1 pound[2]	24	1	25	c, d	([3])	
2 pounds[2]	24	1	25	c, d	23	100.0
4 pounds[2]	24	1	25	c, d	([3])	
Naphthalene flakes	*Days*					
In open trays	7	1	25	a	68	85.3
In paper bags	12	3	75	a, c	671	100.0
In paper bags	42	2	200	f	710	100.0

	Hours					
Pyrethrum smudge	4	2	50	t	202	9.9
Nicotine sulfate dust	*Days*					
In open trays	7	1	25	a	38	28.9
In paper bags	2	1	25	a	40	35.0
Pyrethrum powder						
In open trays	26	1	25	a	34	100.0
In paper bags	26	1	25	a	106	28 3
Soap solution	*Hours*					
1 200 dilution	1	1	25	t	45	84 4
1 100 dilution	1	1	15	c, t	74	71.6
1 50 dilution	1	1	25	c	83	71.1
Nicotine sulfate and soap solution	1	1	25	t	40	85 0
Pyrethrum and soap solution	1	1	25	t	18	83.3
Glue solution						
1 40 dilution	1	1	25	t	10	15.0
1 20 dilution	1	1	25	t	41	22.0
Lye solution	8	1	25	b	13	30.8
Mercuric chloride	1	2	50	t	120	97 6
	2	1	25	t	107	100 0
	3	9	225	a, b c, t,	922	98 7
	8	1	5,000	a, c d, e, t	(4)	
	Minutes					
Calomel	5	2	50	a	82	8.5
Ceresan	10	2	50	a	42	57.1
	30	1	25	t	(5)	
	Hours					
	1	1	25	t	62	100 0
Semesan	1	2	50	t	173	100.0
	2	1	25	t	107	100.0
	3	2	50	t	141	100.0
	7	2	50	a	166	100.0
Carbolic Acid						
1 80 dilution	3	2	50	a, c	419	100 0
1 120 dilution	3	4	100	a, b, c	259	100.0
1-160 dilution	3	2	50	a, c	578	92.2
Vapor heat						
110°F. and 67 per cent relative humidity	1	1	25	f	35	17 1
	2	1	25	t	30	40.0
	3	1	25	t	63	55.6
110°.F and 90 95 percent relative humidity	2	1	25	f	20	95.0
	4	1	25	t	38	100.0

TABLE 1. *Concluded*

Treatment	Duration of treatment *Minutes*	Tests *Number*	Corms treated *Number*	Corms treated *Variety*[1]	Total insects examined *Number*	Average insects killed in tests *Per cent*
Hot water immersion						
108°F.	10	1	20	f	71	49.3
	20	1	20	f	42	45.2
110°F	20	3	60	f	469	100.0
112°F	20	3	60	f	476	100.0
	20	1	500	e	270	88.9
	30	1	500	e	209	100.0
114°F	10	1	20	f	92	100.0
	20	2	35	f	344	100.0
116°F	20	1	15	f	188	100 0
	Hours					
Checks immersed in water	3	3	75	a, c, f	457	42 9
	8	1	25	b	55	80.0
Untreated checks	([6])	3	45	a, c, f	1,422	0.6

[1]a—America, b—Crimson Glow, c—King, d—Los Angeles, e—President Harding, f—Primulinus mixed.
[2]Amount used per 1,000 cubic feet of space.
[3]Uninfested corms. [4]No counts made. [5]Ineffective, no counts made
[6]No treatment.

DISCUSSION OF EXPERIMENTS.—*Effective treatments.* As will be observed in the preceding table, fumigation with calcium cyanide used at the rate of 1¼ ounces or more per 1,000 cubic feet of space was highly effective against the thrips in the larval, pupal and adult stages on corms with dry scales. In the 7 fumigations at the 1¼ ounce rate the kill of insects was complete except in 1 test where 2 larvae survived on 1 corm, apparently because of the protection given them by a large hard exudate from a scab-infected area. The gas seemed to penetrate the scales readily, since the insects were killed beneath as many as 6 layers of scales on corms in the bottom of trays covered by other corms to a depth of 4 inches. However, since the eggs within the corm tissue were apparently unaffected and hatched normally, a second fumigation was required in order to destroy infestation. Life history studies[3] show that the incubation period varies with the temperature and that the larval and egg stages are approximately equal in duration at any given temperature. With this information as a basis the second fumigation was made shortly after the first hatching larvae had entered the pupal stage, at which time the last eggs had hatched. This procedure resulted in a complete cleanup of the thrips in the experimental lots at the lethal

[3]Smith, Floyd F., and Nelson, R. H. Life history studies of the gladiolus thrips. Jour. Econ. Ent. Vol. 26, pp. 528–536, 1933.

dosages, 1¼ ounces or higher. Because of the variation of temperature in different parts of a storage house and because of the difficulty the average grower has in determining the time for making the second fumigation by observing the development of the insect, it is recommended that 3 fumigations at 10-day intervals be made regardless of the temperature. Since the dormant corms are tolerant of fumigation with high dosages of calcium cyanide, it is recommended that 5 ounces of the fumigant be used commercially per 1,000 cubic feet in order to allow for loss by leakage and by adsorption and still insure proper kill.

Fumigation with the ethylene dichloride-carbon tetrachloride mixture, originally recommended by Dustan[4] at the rate of 14 pounds per 1,000 cubic feet at a temperature of 70° F. for 24 hours, was effective at 60° F., even with as short an exposure as 8 hours at the 14-pound dosage. One test at 70° F., using 10.7 pounds per 1,000 cubic feet of space, was also effective. Since the eggs also are apparently killed by this treatment, only one fumigation is required. These tests indicate that shorter exposures and lower dosages than were originally recommended may be used to obtain a complete kill, but until these tests are checked further Dustan's recommendation should be followed The proper dosage is an important point, since overdosages (56 pounds per 1,000 cubic feet) were found to result in severe injury to the corms. Small-scale growers, fumigating their stock in a 5-gallon lard can, have been observed to use 5 or 6 teaspoonfuls of the liquid, whereas 1 teaspoonful is the proper dosage at the 14-pound per 1,000 cubic feet rate. The injured corms, which are a complete loss, become soft, punky, and caramel colored and spotted with fungal growths, but retain their shape until they gradually dry and shrivel.

Naphthalene flakes when mixed among corms in paper bags at the rate of 1 ounce per 100 corms, killed all of the thrips after an exposure of 12 days or longer. The material acts as a fumigant, so a covering of paper or light canvas over the stacked trays in commercial houses seems necessary to concentrate the fumes and effect a complete kill. However, fumigation in a tight container, as a metal can, is not recommended because the corms sweat and sprout. Since the naphthalene is slowly volatile it acts for a considerable period of time even after the last eggs have hatched. No damage has been observed when dormant corms

[4]Dustan, Alan G. Recommendations for the Control of the Gladiolus Thrips in 1932, Canadian Department of Agriculture, D. F. C. & G. I. No. 102, Ottawa No. 35 (mimeographed circular). Also Dustan, A. G. and Bryce, P. I. Recommendations for the control of Gladiolus Thrips. The 1932 Canadian Gladiolus Annual 9: 61–64. 1932.

have been in direct contact with the material for as long as 4 months, which indicates that an overdosage will not be dangerous to the dormant stock. However, since naphthalene applied in the soil about the corms results in injury,[5] excess flakes should be shaken out and the corms aired for a short time before planting. Because of the high tolerance of the dormant corms to naphthalene, its low cost, ease of application, and effectiveness against the thrips, this material seems to be one of the best for use by the small-scale grower and also for the average large-scale grower who lacks special equipment for successfully using some of the other treatments

As shown in the table, immersion in a 1–1,000 solution of mercuric chloride for periods of 1 to 3 hours, as used for disease control, gave a high but incomplete kill of the thrips. In the series of 9 tests at the 3-hour period the kill was complete in 4, but a few thrips survived in 5 tests. The survivors, however, were in sufficient numbers to renew the infestation. In 1 test where the stock was immersed for 8 hours and planted, no thrips appeared on the foliage or flowers during the growing season, which indicated the effectiveness of the treatment. However, because of the poor wetting qualities of this material it can not be relied upon to give a complete cleanup of the thrips Commercial growers who have used it for as long as 17 hours as a dip obtained incomplete control on certain varieties. The survivors were usually found in the cavities about the buds at the top of the corm, where they were evidently protected in an air pocket

Immersion of corms in a 2 per cent suspension of semesan (containing 30 per cent hydroxymercurichlorophenol) for 7 hours, as used for disease control, killed all thrips. Immersion periods as short as 1 hour also gave a complete kill, even though the insects beneath the scales in corm cavities were not wetted. Evidently a volatile substance which is given off by semesan has an insecticidal action against the thrips and is effective even after the corms have dried following treatment. The presence of this toxic volatile substance was demonstrated by bubbling air through a 2 per cent water suspension of semesan and passing it over corms infested with thrips, which died from 20 to 30 hours later. Thrips were killed by passing air over the dry powder into the chamber containing the insects. These tests indicate the possibility of killing the thrips, on corms, by a relatively short immersion in semesan which would allow some of the material to adhere to the scales, or by mixing the dry chemical with the corms in a dust carrier where the action would be as a fumi-

[5]Richardson, Henry H., and Nelson, R. H. 1932. Field control of the gladiolus thrips. Jour. Econ. Ent. Vol. 26, pp. 546-554, 1933.

gant similar to naphthalene. The effectiveness of such short treatments as the 1-hour dip has not been determined where used immediately before planting, but a 7-hour treatment was effective commercially. The scales on corms dipped in semesan became darkened and the outer leaves on the dormant buds of some corms were slightly injured and became brown and shriveled. The subsequent growth and flowers from such corms were not injured, however.

Commercial liquid carbolic acid (88 per cent phenol), when diluted with water at proportions of 1-80 and 1-120, killed the thrips on corms immersed for 3 hours, but was ineffective at a dilution of 1-160, as is shown in the table. This treatment did not visibly injure the dormant corms, but shoots and roots, starting into growth on the other corms, were injured. The mites *Tyroglyphus lintneri* Osborn were killed by all dilutions. Further work is required before conclusions will be drawn on the value of this treatment, particularly as to the tolerance by some varieties.

Vapor-heat treatments on small lots of corms indicate that a 1-hour heating at 110° F. and a high relative humidity will kill the thrips and the eggs. Lower humidity reduces the effectiveness of the treatment, as is indicated by the results in the table showing that 40 and 95 per cent of the thrips were killed by 2-hour treatments with relative humidities of 67 and 90 to 95 per cent, respectively.

Tests for control by hot-water immersion show that a 20-minute treatment at 110° to 116° F. is required to kill thrips on small lots of corms. However, larger quantities of corms will require longer treatment, as was shown in each of two tests where nearly a bushel of corms were treated in a burlap sack. A 30-minute treatment at 112° F. was required to penetrate the greater mass and effect a complete kill. No corm injury resulted from any of these treatments by vapor heat or hot-water immersion, but the corms were stimulated into earlier growth following planting in the greenhouse during the late winter, or into earlier sprouting when stored at 60° F. The heat treatments would be useful in the certification of stock for shipment, but their use will probably be limited because special equipment is required.

Ineffective treatments. The materials discussed under this heading either did not kill the thrips or they injured the corms under the conditions of the experiments. Possibly modifications of some of these treatments will make them effective.

Fumigation with ethylene oxide at the dosages used killed the corms as well as the thrips.

Pyrethrum smudge was ineffective against the thrips beneath the

scales. Heavy applications of nicotine and pyrethrum dusts to corms in paper bags were not effective against the thrips beneath the scales. Immersing the corms for one hour in solutions of soap, nicotine sulphate and soap, pyrethrum and soap, glue, or potassium hydroxide, or in water for periods up to 8 hours were ineffective as control. None of these treatments injured the corms.

Immersing infested corms for 10 minutes in ceresan or for 5 minutes in calomel, as is done in disease control, was not effective against the thrips. A 30-minute dip in ceresan was ineffective, but in one test where a 1-hour immersion was used all thrips were dead when examined 6 weeks later. The results of this test are questioned, since the thrips may have died from other causes. No corm injury resulted from any of these tests.

Effect on the growth following treatment. From the past year's work the drawing of definite conclusions on the effect of the various corm treatments upon the succeeding crop is complicated for the following reasons: (1) The treatments were made at various times during the winter from December to March. (2) The corms were not all injured to the same extent by the feeding of the thrips. (3) The soil in which the lots were planted varied in its composition in different areas. However, it was apparent that, except for the stimulation produced by heat treatments or by fumigation with the ethylene dichloride-carbon tetrachloride mixture and the retardation produced by mercuric chloride or by semesan dips, no marked effect on the growth, flowering, and corm production resulted when no effects were visible on the corms before planting.

Residual action of corm treatments. An important point in the practical use of a thrips control on the corms is the matter of reinfestation following treatment. Fumigation with calcium cyanide or ethylene dichloride-carbon tetrachloride and the treatments with vapor heat or hot water were effective against the thrips present at the time, but did not have residual action and prevent later reinfestation. The treatment with mercuric chloride gave only partial protection in laboratory tests. The efficiency of the phenol dip in this respect has not been tested. Naphthalene flakes and semesan, because of the persistence of the materials on the corms, where they act as slow-acting fumigants, give the most prolonged protection, but the extent of this protection requires further study. If the treatment finally selected does not possess a residual effect and give this protection, precautions must be taken to prevent the thrips from gaining access to the treated stock from the untreated. These precautions should take cognizance of the fact that the thrips can be carried on the clothing, among hairs on the bare arms, and on trays or

other utensils, and that they will move about among the corms in storage.

CONCLUSIONS.—Based on the results of these preliminary experiments, 8 of the 19 materials or treatments tested in the laboratory for the control of thrips on unscaled gladiolus corms in storage showed a high degree of efficiency by killing the thrips and not seriously injuring the corms. Because calcium cyanide kills all stages except the eggs, a second fumigation is required after the eggs have hatched. Three fumigations at 10-day intervals, using a dosage of 5 ounces per 1,000 cubic feet, are recommended. A 24-hour fumigation using 14 pounds of ethylene dichloride-carbon tetrachloride mixture per 1,000 cubic feet killed all stages of the insect and only one treatment was required. The effectiveness of 8 and 12 hour exposures was indicated in limited tests, but at present these shorter periods are not recommended. Treatments by vapor heat for 4 hours at a temperature of 110° F. and 95 per cent relative humidity, or by immersion in hot water for 20 minutes at temperatures of 110° to 116° F., killed the egg as well as the other stages in small lots of corms. When larger lots are treated, the treatment is necessarily longer. These four treatments do not have residual effects to prevent later reinfestation. A 3-hour immersion of corms in a 1–80 or 1–120 dilution of phenol solution killed all the thrips, but the status of this material requires further study. Immersion in a 1–1,000 dilution of mercuric chloride for 3 hours resulted in a high but incomplete kill of the thrips and only partial protection following treatment. Application of 1 ounce of naphthalene flakes to 100 corms or an immersion for 1 to 7 hours in a 1–50 semesan suspension gave a complete kill of the thrips, and since these materials function as slow-acting fumigants the corms are protected from reinfestation for a longer time than with any of the other treatments.

The heat treatments and fumigation with ethylene dichloride-carbon tetrachloride mixture hastened the breaking of dormancy of corms when used as recommended. Increasing the dosage of the latter to 56 pounds per 1,000 cubic feet injured the corms, so the use of this material at higher rates than 14 pounds per 1,000 cubic feet or 1 teaspoonful to a 5-gallon receptacle is inadvisable. Treatment in mercuric chloride or in semesan delayed the starting of growth after planting, but the effects were not permanent. The evidence indicated that none of the treatments otherwise affected the resulting growth, flowering, or corm production where the corms were not visibly affected at planting time.

FIELD CONTROL OF THE GLADIOLUS THRIPS (*TAENIOTHRIPS GLADIOLI* M. & S.)

By Henry H. Richardson and R. H. Nelson,[1] *Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology, Washington, D. C.*

Abstract

Paris green-brown sugar spray, a lead arsenate combination spray, and nicotine tannate, as well as three other sprays, were tested, each on 15 small plots during the 1932 season (8 applications at weekly intervals). Each small plot contained two red varieties of gladiolus, Crimson Glow and Brilliant, which had been uniformly infested with the gladiolus thrips. Paris green-brown sugar spray was by far the most efficient, not only in controlling the thrips, but also in reducing thrips injury to the flowers. Data on the number and size of flowers, foliage development, and number and size of corms harvested indicated that the pine tar oil-nicotine spray, as well as the nicotine sulfate-soap spray, especially the latter, had a distinctly injurious effect on the plants. Of the five other insecticides that were tested on a smaller scale at this same field, the white oil-nicotine spray was most effective, but this did not approach the Paris green-brown sugar spray in efficiency. A total of 14 insecticides, including all the above, were tested at another field for their effect on uninfested gladiolus (variety Alice Tiplady). Only the nicotine sulfate-soap spray had any distinctly injurious effect (as evidenced by flower and corm production). Preliminary experiments indicated that one or two applications of naphthalene, paradichlorobenzene, tobacco dust, carbon disulphide emulsion, or ethylene dichloride emulsion, applied to the soil just after planting corms, would not be effective for controlling the thrips. Naphthalene and paradichlorobenzene (especially the latter) greatly retarded the growth of the plants and evidently caused some reduction in the corm and flower production. The gladiolus thrips does not appear to move about much during the growing and early blooming season, but considerable numbers do migrate, apparently close to the ground, after the flowers are cut. Muslin barriers 3 feet high erected between treated plots were apparently effective up through flowering time in reducing any slight movement of thrips from one plot to another. Observations of the predator *Orius insidiosus* (Say) indicated that it can kill as many as 30 thrips per day and that it might reduce thrips populations in small isolated plots.

No matter how effective the corm treatments for gladiolus thrips control may be, it will apparently always be necessary to have some measures available for controlling this thrips on the growing plant in the field. This would be of benefit especially to the grower who has failed to apply effective corm treatments and to the home gardener who accidentally plants infested corms, as well as to growers in such sections as California and Florida, where adjacent fields of gladiolus are brought into bloom during every month of the year.

The experiments reported here were made to determine the effective-

[1]The authors wish to acknowledge with thanks the aid given by Drs. C. A. Weigel and Floyd F. Smith. Mr. A. T. Grimes. and Dr. J. W. Bulger at various times during the progress of the experiments.

ness against the gladiolus thrips of a number of sprays and dusts applied eight times at weekly intervals during the growing season. Field tests were also made to ascertain the tolerance of the plant to the spray when no gladiolus thrips were present. The results of a few preliminary experiments with soil insecticides, as well as some notes on thrips migration, are also reported.

INSECTICIDES TESTED.—The following insecticides were used:

Paris green-brown sugar		
Paris green	1	ounce
Brown sugar	2	pounds
Water	3	gallons
Nicotine tannate		
Nicotine solution (50 per cent)	½	pint
Tannic acid[4]	1	pound
Ferric oxide skim milk	1	pound
Water	50	gallons
Pine tar oil nicotine		
Saponified pine tar oil	2	quarts
Nicotine sulfate (40 per cent)	6	fluid ozs
Water	50	gallons
Pyrethrum soap		
Pyrethrum extract	1	fluid oz
Soap (40 per cent concentrate)[6]	1½	fluid ozs
Water	1	gallon
'White' oil nicotine		
Oil concentrate[5]	12	fluid ozs
Nicotine sulfate (40 per cent)	1	fluid oz
Water	8	gallons
Soap		
Soap (40 per cent concentrate)[6]	1½	fluid ozs
Water	1	gallon
Nicotine dust		
Hydrated lime	95	pounds
Nicotine sulfate (40 per cent)	5	pounds
Lead arsenate combination[3]		
Lead arsenate	1½	pounds
Nicotine sulfate (40 per cent)	1	pint
Waste sulfite liquor	1½	quarts
Water	50	gallons
Bordeaux nicotine		
Copper sulfate	4	pounds
Hydrated lime	6	pounds
Nicotine solution (50 per cent)	12	fluid ozs
Water	50	gallons
Nicotine sulfate-soap		
Soap (40 per cent concentrate)[6]	5	pints
Nicotine sulfate (40 per cent)	11	fluid ozs
Water	50	gallons
Derris soap		
Derris extract[8]	2	fluid ozs
Soap (40 per cent concentrate)[6]	9	fluid ozs
Water	6	gallons
Paris green-nicotine		
Paris green	1	ounce
Nicotine sulfate (40 per cent)	½	fluid oz
Water	3	gallons
Sulfur dust		
Wettable flotation sulfur	80	per cent
Inert material	20	per cent
Pyrethrum dust		
A pyrethrum powder-china clay mixture plus pyrethrum extract to make the mixture contain 0.8 per cent pyrethrins		

[2]The formula used here is a modification (only about one-half the quantity of Paris green is used) of that recommended by A. G. Dustan of the Canadian Department of Agriculture for gladiolus thrips control. Dustan, A. G. "The Gladiolus Thrips and its Control," Canadian Dept. of Agriculture D. F. C. & G. I. mimeographed circular

ARRANGEMENT OF EXPERIMENTS.—Small plots were used entirely throughout the tests. The field control experiments were made at Takoma Park, Md. Six sprays were tested on a total of 90 small plots each containing 40 infested gladiolus of the variety Crimson Glow and 25 of the variety Brilliant. Untreated check plots were laid out 100 feet away from the treated ones. Five other sprays and dusts were tested on a small scale at this same field, a total of 15 small plots being used. All the above sprays and dusts as well as three others were tested for their effect on uninfested plants at the Arlington Experimental Farm in Virginia. Here 57 small plots were planted, each containing 20 uninfested gladiolus, variety Alice Tiplady. Each insecticide was tested on 3 small plots; 15 small plots distributed evenly throughout the field were used as checks.

THRIPS CONTROL EXPERIMENTS.—Two red varieties of gladiolus, Crimson Glow and Brilliant, were chosen for the thrips control experiments because the thrips injury would show very strikingly on these. The corms of No. 2 size were uniformly infested with the gladiolus thrips, so that by the time of planting from 5 to 15 active thrips in various stages could be found on any one corm. The Crimson Glow were more heavily infested than the Brilliant; apparently the tighter husk of the Brilliant might account for this. The 15 small plots used in each treatment were planted so that when comparisons of results were desired each small plot could be paired directly with a similar plot in another treatment.

The corms were all planted on May 26. They sprouted normally and within 2 weeks the shoots were 3 to 4 inches above ground and quite

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No. 101, p. 4, 1931; and Dustan, A. G., and Bryce, P. I., "Recommendations for the control of Gladiolus Thrips," The 1932 Canadian Gladiolus Annual *9*:61–64.

[3]This is a formula recommended by E. A. Herr in "The Gladiolus Thrips," Ohio Agricultural Experiment Station, 1931, mimeographed circular. Also in the "Report of the 11th Annual Conference of North Central States Entomologists," Wooster, Ohio, March 3-4, 1932, pp. 32–34, mimeographed.

[4]Tannic acid obtained from Chinese galls was used. Care was taken that all tannic acid was in solution before adding nicotine.

[5]Saponified pine tar oil, containing 56 per cent of a pine tar oil, boiling range 100–240°C., specific gravity 0.900 to 0.910 at 15.5°C.; saponified with caustic soda and rosin.

[6]Soap. A potassium-cocoanut oil soap.

[7]Pyrethrum extract. Alcoholic extract containing 1.8 grams pyrethrins per 100 cc.

[8]Derris extract. An acetone extract containing 2.3 grams of rotenone per 100 cc. as well as other derris extractives.

[9]Oil concentrate, containing 83 per cent highly refined petroleum "white" oil by volume; with a casein emulsifier.

uniformly infested with thrips. The spray and dust applications were started June 14 and were made weekly thereafter. When rain interfered, the applications were postponed until the next sunny day. Sprays were applied with a knapsack sprayer at approximately 60 pounds pressure. Dusts were applied with a hand duster of the pump type. A total of 8 applications were made as follows: June 14, 21, and 29, July 5, 12, 18, and 26, and August 4. About 6 weeks after planting, muslin barriers (3 feet in height) were erected between plots to prevent movement of the thrips from one plot to another. By the time of the last spray application a few flowers of the Brilliant variety had started to bloom. Flower cutting was commenced August 9 and continued thereafter at 2-day intervals (in one case 3 days) until August 24, at which time the majority of the flowers had bloomed. Cuttings were also made on September 1, 10, and 14. Flowers were graded by the length of the spike and size of the individual florets into the categories: Small (No. 1), medium (No. 2), and large (No. 3). Owing to natural varietal differences, Crimson Glow flowers were distinctly larger than those of the Brilliant. Flowers were graded as to thrips injury as follows:

Grade 1—No thrips injury, highest class of salability.
Grade 2—Very slight injury, 1 or 2 white specks where thrips had fed on one floret Second class salability.
Grade 3—Slight injury, margins of 1 or 2 petals of 1 or 2 florets crimped from thrips feeding. Few white flecked areas on petals themselves. Third class salability
Grade 4—Moderate injury, noticeable streaking of petals where thrips had fed. Numbers of petals with crimped and curled margins. Not salable.
Grade 5—Severe injury, florets were distorted and did not open normally Considerable crimping of margins of petals and large streaked areas on petals and sepals. Not salable.
Grade 6—Very severe injury, flowers so badly damaged that they did not open. Some flower spikes dried before color showed on bud sheath. Not salable.

On August 19, 50 florets of each variety (the 2nd floret above the last fully opened floret) were collected in groups of 10 from each treatment. Each group of 10 was collected at random from each of five sections in the treatment (each section consisting of 3 small plots). The florets were later examined under binocular microscopes and counts were made of the number of thrips present. Table 1 shows the results of these thrips counts and summarizes the records on thrips injury to the flowers.

In judging the effectiveness of the sprays, emphasis should be placed on the results with the Crimson Glow, as this variety without doubt was

more heavily infested and the sprays were thus subjected to a more severe test of efficiency. It is evident from the results, as shown in Table 1, that the Paris green-brown sugar spray was by far the most

TABLE 1. EFFECTIVENESS OF VARIOUS SPRAYS[1] IN CONTROLLING THE GLADIOLUS THRIPS AND IN REDUCING THRIPS INJURY TO FLOWERS, TAKOMA PARK, MD. EACH SPRAY WAS TESTED ON 15 PLOTS, EACH PLOT CONTAINING 40 PLANTS OF CRIMSON GLOW AND 25 PLANTS OF BRILLIANT

Sprays	Total thrips found in florets[2]	Average thrips per floret	Total flowers harvested	Grade 1 flowers	Total salable[3] flowers	Total unsalable[4] flowers
	Number	*Number*	*Number*	*Per cent*	*Per cent*	*Per cent*
I. Results with Crimson Glow						
Paris green-brown sugar	31	0.6	538	72.6	89.8	10.2
Lead arsenate combination..	116	2.3	533	29.2	68.5	31 5
Nicotine tannate .	183	3.7	498	23.6	57.6	42.4
Bordeaux-nicotine	361	9.0	522	0.8	10.8	89.2
Nicotine sulfate-soap .	685	13.7	333	0 0	3.3	96.7
Pine tar oil-nicotine .	1,000	20.0	471	0.0	0.4	99.6
II. Results with Brilliant						
Paris green-brown sugar	11	0.5	323	82.3	95.5	4 5
Lead arsenate combination .	26	1.0	333	66.9	93.0	7.0
Nicotine tannate .	35	1.4	312	65.0	91.2	8.8
Bordeaux nicotine	143	5.8	327	7.3	62 3	37.7
Nicotine sulfate-soap. . .	273	11.9	293	0.3	36.5	63.5
Pine tar oil-nicotine .	386	15.4	310	0.3	35.4	64.6

[1]The untreated check plots were located some distance away from the treated plots and very low thrips infestations were present. The predator *Orius insidiosus* (Say) was present in large numbers. Laboratory studies by the junior author have shown that this insect can kill as many as 30 thrips per day. The large numbers of Orius in the checks might account for the small numbers of thrips present. Very few if any Orius could be found in the treated plots. In view of these complicating factors, as well as differences in the soil, the data taken from the check plots were of no comparative value for determining the effectiveness of the sprays, and comparisons are limited to the results obtained among the various sprayed plots themselves.

[2]All of the 50 florets of Crimson Glow collected from each treatment were examined, except those from the Bordeaux-nicotine test, of which 40 were examined. In the Brilliant from 22 to 25 from each treatment were examined.

[3]Salable flowers included grades 1, 2, and 3.

[4]Unsalable flowers included grades 4, 5, and 6.

efficient not only as regards thrips control but also as to the production of first class flowers and the total of salable flowers. The other materials are shown in the order of their efficiency. The results were consistently the same on both varieties of gladiolus. There is apparently a direct (positive) correlation between the numbers of thrips present and the amount of injury done to the flowers.

Shortly after blooming time, notes were made on the average height and condition of the foliage, the thrips injury to the foliage, and the presence or absence of spray deposits. The corms were dug October 11

and 12, placed in trays, cleaned of old corms November 4, and counted and weighed November 11. The data from these examinations are summarized in Table 2.

TABLE 2. FLOWER PRODUCTION, FOLIAGE DEVELOPMENT, AND WEIGHT OF CORMS HARVESTED ON INFESTED GLADIOLUS TREATED WITH VARIOUS SPRAYS, TAKOMA PARK, MD.

Spray	Average number flowers per plot	Average size of flowers[1]	Average height of foliage at maturity	Average number of corms harvested per plot	Average weight of corms harvested per plot	Average weight of corms harvested
			Inches		*Grams*	*Grams*
I. Results with Crimson Glow (40 Corms in Each Plot, 15 Plots per Treatment)						
Paris green-brown sugar	35.9	2.604	27	36.7	1,064	28.99
Lead arsenate combination .	35 5	2.285	28	36.6	962	26.28
Nicotine tannate . .	33.2	2.367	27	37.0	970	26.21
Bordeaux-nicotine	34.8	2.068	27.5	36.1	891	24.70
Nicotine sulfate-soap .	22.2	1.714	20	30.9	491	15.88
Pine tar oil-nicotine	31.4	1.919	24	35.4	816	23.05
II. Results with Brilliant (25 Corms in Each Plot, 15 Plots per Treatment)						
Paris green-brown sugar .	21.5	2.761	20.5	22.5	423	18.81
Lead arsenate combination	22.2	2.642	20.5	24.3	463	19.07
Nicotine tannate .	20.8	2.580	20.5	24.4	471	19.29
Bordeaux-nicotine	21.8	2.333	20.5	24.0	407	16.97
Nicotine sulfate-soap .	19.5	2.098	14.5	22.1	.08	13.95
Pine tar oil-nicotine.	20.7	2.274	17.5	23.4	407	17.41

[1]Small flower = 1.000, medium flower = 2.000, large flower = 3.000.

The data presented in Table 2 indicate that the first four sprays had little effect on the plant. The pine tar oil spray plots and the nicotine sulfate-soap spray plots are distinctly lower as regards size of flower and height of foliage. Nicotine sulfate-soap plots were also significantly lower as regards the production in number and size of corms and number of flowers. It appears that these two sprays were not only ineffective in controlling the thrips but they also (especially nicotine sulfate-soap) exerted an injurious effect on the plant. Whether this was a direct spray injury or whether the spray provided a favorable environment for the development of disease is a question. The fact remains that the corms harvested from these plots were considerably distorted, had poor husks, and were distinctly more diseased.[10] (Scab *Bacterium marginatum* McCulloch.)

Spray injury and spray deposits. Paris green-brown sugar spray apparently causes some injury to the growing foliage, for usually 2 or 3

[10]The authors are indebted to Miss Lucia McCulloch, of the United States Bureau of Plant Industry, for examination of the corms and identification of the organism.

of the lowest leaves were entirely dead, and a few dead spots were scattered over the upper leaves when the plant matured. Apparently the injury done by the Paris green-brown sugar spray was only of a temporary nature and of no great importance to the final number and size of flowers produced, to the height and vigor of the foliage, and to the corm production, for with the most heavily infested variety (Crimson Glow) the Paris green-brown sugar plots led all others in these respects. The sticky residue left by this spray is easily washed off by rain. In future tests it might be found possible to reduce the number of Paris green-brown sugar applications by spraying at greater intervals and renewing the application only after rains have washed off the spray residue.

Both the lead arsenate spray and the nicotine tannate spray left insoluble residues that might reduce the attractiveness of the foliage.

Insecticides Tested on Smaller Scale.—The same procedure as used with the large-scale tests was followed with these experiments. The data on thrips population and thrips injury to flowers have been gathered and are summarized in Table 3.[11]

Table 3. Results of Small-scale Thrips Control Tests, Takoma Park, Md. (Each Spray was Tested on 3 Plots, Each Plot Containing 40 Plants of Crimson Glow and 25 Plants of Brilliant)

	Crimson Glow			Brilliant[1]	
Insecticide	Average thrips population per floret	Grade 1 flowers	Total salable flowers[2]	Grade 1 flowers	Total salable flowers[2]
	Number	*Per cent*	*Per cent*	*Per cent*	*Per cent*
White oil-nicotine	2.4	17.5	67.1	36	94.0
Derris-soap	3.2	7.8	37.7	24.4	73.2
Pyrethrum-soap	6.7	4.5	15.8	10.5	71.0
Sulfur dust	18.7	3.4	12.4	6.2	43.4

[1]No thrips population counts were made on the Brilliant. As in other Brilliants examined at this same field, however, the thrips populations were probably very much lower than those in the Crimson Glow.

[2]Salable flowers included grades 1, 2, and 3.

The most effective of these treatments appears to be the white oil-nicotine sulfate combination, though this spray does not compare favorably in efficiency with the Paris green-brown sugar spray. It is apparently about the equal of the lead arsenate combination spray. Derris extract-soap and pyrethrum extract-soap sprays follow in the order named. Sulfur dust was by far the least effective.

[11]These same plots had previously been used for unsuccessful soil insecticide tests. Hence the data on flower and foliage development and on corm production could not be used in judging the sprays and dusts.

TOLERANCE TESTS ON UNINFESTED PLANTS.—For these tests the gladiolus corms (variety Alice Tiplady) were planted May 6, 1932. Spray and dust treatments were applied (at weekly intervals if rain did not interfere) as follows: June 2, 8, 17, and 23, July 1, 7, 15, and 22. Flowers were cut and graded as to size on July 29 and August 16 and 24. The corms were harvested October 21, placed in trays, cleaned November 4, and counted and weighed November 11. The results are summarized in Table 4.[12]

TABLE 4. RESULTS OF PLANT TOLERANCE TESTS ON UNINFESTED GLADIOLUS AT THE ARLINGTON EXPERIMENTAL FARM IN VIRGINIA. (EACH INSECTICIDE WAS TESTED ON 3 PLOTS EACH PLOT CONTAINING 20 PLANTS OF GLADIOLUS, VARIETY ALICE TIPLADY)

Insecticide	Treated plots: Average number of flowers per plot	Treated plots: Average size of flowers[1]	Treated plots: Average weight of corms per plot (Grams)	Check plots: Average number of flowers per plot	Check plots: Average size of flowers[1]	Check plots: Average weight of corms per plot (Grams)
Paris green-brown sugar	20.0	1.82	870	21.3	2.19	940
Lead arsenate combination	14.3	1.79	547	14.6	1.98	590
Nicotine tannate	21.3	2.28	910	23.6	2.31	1,047
Bordeaux nicotine	14.3	2.00	557	13.3	1.78	570
Nicotine sulfate-soap	11.0	1.39	523	16.0	1.75	773
Pine tar oil-nicotine	19.3	2.05	973	21.6	2.25	1,073
Paris green-nicotine	16.0	2.06	600	13.6	2.22	660
Pyrethrum-soap	14.0	1.71	617	15.6	2.09	713
Derris-soap	9.6	1.90	630	15.6	1.77	630
Soap..	12.3	1.89	673	12.6	1.97	540
White oil-nicotine	13.3	1.70	590	13.6	2.00	640
Pyrethrum dust	18.0	1.98	843	17.0	2.18	697
Sulfur dust	10.3	1.55	497	13.0	1.77	630
Nicotine dust	21.0	2.17	983	16.0	1.94	800

[1]Small flower = 1.00, medium flower = 2.00, large flower = 3.00.

The plots given the various treatments had been scattered at random over this field so that no one treatment was repeated in the 4 long rows. As the season progressed, however, it was noted that the soil conditions, as evidenced by the growth of the plants, varied greatly over the field. Those plants near the east end were much more vigorous and produced more flowers and greater numbers of larger corms. Hence direct comparisons among the treated plots can not be made. However, as each treated plot had an untreated check very close by (there were 15 untreated check plots), direct comparison could be made between these.

[12]Early in the growing season a considerable infestation of the tobacco thrips, *Frankliniella fusca* Hinds, developed in this experimental field. On June 8 the checks were also sprayed in order to prevent any thrips injury on the checks from interfering with the comparative results. However, the following week the tobacco thrips started to migrate out to tobacco and other plants near by and no further sprays were applied to the checks.

The nicotine sulfate-soap plots were the only ones in which the production of both flowers and corms was significantly lower than that of the untreated check. The indications are that none of the other sprays had any distinctly injurious effect on the plants. This result with the nicotine sulfate-soap spray corroborates what was found in the thrips control tests on the Crimson Glow and Brilliant varieties.

Soil Insecticide Tests.—A number of soil insecticides, applied shortly after planting infested corms, have been tested to ascertain whether it would be possible to control thrips in this way. Naphthalene flakes (2 ounces to 50 corms), paradichlorobenzene crystals (1 ounce to 50 corms), tobacco dust (1 pound to 50 corms), carbon disulphide (1-750 emulsion, 1 gallon to 50 corms), and ethylene dichloride (1-750 emulsion, 1 gallon to 50 corms) were tested on corms of Crimson Glow and Brilliant. The treatments were applied to the soil from 1 to 1½ inches above the corms the day after planting More soil was then drawn in over the row. Some plots were given a second application 11 days after planting.

None of these chemicals with either one or two treatments was completely effective against the thrips There was some doubt concerning the results in the plots in which two applications of naphthalene or ethylene dichloride were made In addition to being ineffective, both naphthalene and paradichlorobenzene (especially the latter) produced a definite retardation in growth and evidently lowered the flower production and weight of corms, especially where two treatments were applied.

Studies on Migration of the Thrips.—Field observations indicate that the gladiolus thrips migrate very little during the growing and early blooming season of the gladiolus Following the cutting of the flowers and maturing of foliage, the thrips, especially on heavily infested plants, move away apparently in search of new plants. This was brought out by studies where sticky fly papers were set up around various plots at from 1 to 3 feet above ground. Of a total of 1,012 thrips caught, 82.3 per cent were taken on papers from 0 to 1 foot above ground and 17.7 per cent from 2 to 3 feet above ground. These figures indicate that large numbers of this species of thrips migrate just above ground. Apparently the muslin barriers which were erected at midseason between the plots of different treatments were effective in stopping what little migration occurred up to flowering time, for the thrips population counts were quite consistent throughout a plot and were not higher near the separating barrier, although the thrips populations differed greatly in adjacent plots, as indicated in Table 1.

GREENHOUSE AND FIELD TESTS FOR THE CONTROL OF THE GLADIOLUS THRIPS)[1] (*TAENIOTHRIPS GLADIOLI* M. & S.)

By Clyde C. Hamilton, Ph.D., *Associate Entomologist, New Jersey Agricultural Experiment Station*

ABSTRACT

The gladiolus thrips probably does not pass the winter in the fields in large numbers in New Jersey. The destruction of waste corms, volunteer plants and other rubbish in and surrounding the field is advisable. The destruction of the thrips on corms in storage may be accomplished by a number of methods such as dipping in mercury compounds, nicotine solutions, fumigating with naphthalene, nicotine dust, pyrethrum dust, calcium cyanide and other materials. In controlling the thrips on the foliage it is necessary to start early, and spray frequently. Dusts containing pyrethrins or rotenone, applied either as dusts or as wet sprays, were more effective than liquid sprays containing either pyrethrins or rotenone. The brown sugar, Paris green and water spray is said to be very effective and considerably cheaper than many other sprays.

The gladiolus thrips was first recorded as injuring gladiolus the summer of 1930. It did extensive damage to plants in 1931 and was even more abundant and injurious the summer of 1932. Preliminary field tests conducted in August 1931 on gladiolus plants heavily infested with thrips indicated the difficulty of controlling this pest after an infestation had become established. Accordingly, arrangements were made to do some experimental work upon controlling the thrips on the corms in the winter and upon plants growing in the greenhouse. The work reported in this paper gives the results of greenhouse experiments the winter and spring of 1932 and some of the field tests the summer of 1932.

The successful control of the thrips may properly be divided into three phases. First, the cleaning up and destruction of all weeds, rubbish, old gladiolus corms and other material in and near the gladiolus field in which the thrips might hibernate during the winter; second, the destruction of the thrips carried into storage on the corms in the fall, thus preventing injury to the corms as well as infesting the plants in the spring after planting and; third, the control of the thrips on the foliage and bloom of growing plants.

If clean up measures are not practiced it is possible that the gladiolus thrips may winter over in the field, and for plants to become infested from these thrips the following year. The greatest source of infestation in the spring is, no doubt, from thrips wintering over on the corms in

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

storage and carried to the field when the corms are planted. Therefore, the importance of eliminating the thrips on the corms.

Tests in Controlling the Thrips on the Corms.—Information from several articles published in the summer and fall of 1931, indicated that there were several procedures which might be followed to rid the corms of thrips. Some of these were fumigating with one of several materials such as calcium cyanide, carbon bi-sulphide, ethylene dichloride 75% and carbon tetrachloride 25%, dipping corms in hot water, a bichloride of mercury solution, or in nicotine or pyrethrum spray solutions, and the storage of the corms at temperatures below 40°F. to prevent development of the thrips.

Late in December 1931, the writer started experiments to determine the efficiency of several methods of destroying the thrips on the corms. The tests were conducted on two varieties of gladiolus, namely Ming Toy, and Alice Tiplady. The corms had been stored in a warm cellar after digging and cleaning and at the time of starting the experiments, were heavily and rather uniformly infested with all stages of the gladiolus thrips. Fifty corms of each variety were used in each test. They were placed in 16 pound heavy paper bags, two bags thick to prevent tearing, and the treatment either made in the bag or, in case of those which were dipped in hot water or insecticide solution, the corms were placed in the bags after drying. The bags were closed by folding over the tops several times and clipping, leaving the air space at approximately ¼ cubic foot. The dosages for the fumigating materials and dustings were figured on the basis of ¼ cubic foot air space. The 50 bulbs filled approximately ⅓ of this space.

The Ming Toy corms were treated on December 16, 1931 and the first examination to determine the number of live thrips were made from December 19 to 22. A second examination of the corms were made on January 28 and 29, 1932. The Alice Tiplady corms were treated December 23, 1931 and the first examination made December 26 and 28. The second examination of these corms was made on January 30 and 31, 1932. Ten corms were carefully examined each time under the microscope and accurate counts made of the adult thrips and the young thrips. The first examination was made to determine the kill of the thrips immediately after treatment and the second examination approximately a month after the treatment to determine the extent of the reinfestation from eggs which might not have been killed. The bags containing the treated corms were kept in the laboratory at a temperature of about 68 to 70° F. in order that development might occur and the results of the treatment obtained in a shorter time.

The materials used in the treatment and the results obtained are given in the accompanying table.

An examination of 15 Ming Toy corms made December 16, before treatment, showed 236 adult thrips and 52 young, a total of 288 thrips or an average of 18 thrips per corm. Twenty untreated Alice Tiplady corms examined December 23, had an infestation of 93 adult thrips and 224 nymphs, a total of 317 thrips, and an average of 15 thrips per corm. The smallest number of thrips found on a single corm was 4 and the largest 53

TABLE I TABLE SHOWING THE NUMBER OF GLADIOLUS THRIPS FOUND ON 10 TREATED CORMS 3 TO 4 DAYS AFTER TREATMENT AND ONE MONTH AFTER TREATMENT

Material used	Amount	Time of treatment	Ming Toy 1st exam.	Ming Toy 2nd exam.	Alice Tiplady 1st exam.	Alice Tiplady 2nd exam.
1. Calcyanide	0.7 gms.	5 hrs	0	92	0	23
2. Calcyanide	0.7 gms	10 hrs.	1	11	0	21
3. Calcyanide	1.5 gms	5 hrs.	0	42	0	0
4. Calcyanide	1.5 gms	10 hrs	0	10	0	1
5. Carbon bisulfide	1.0 cc	5 hrs.	60	94	2	17
6. Carbon bisulfide	1.0 cc.	10 hrs.	73	97	21	18
7. Carbon bisulfide	2.0 cc	5 hrs	46	98	104	25
8. Carbon bisulfide	2.0 cc	10 hrs	45	149	99	9
9. Paradichlorobenzene	0.5 gms		7	135	57	10
10. Paradichlorobenzene	1.0 gms		6	102	12	31
11. Paradichlorobenzene .	2.0 gms		0	83	1	31
12. Naphthalene	0.5 gms		16	197	2	11
13. Naphthalene	1.0 gms.		9	102	1	1
14. Naphthalene .	2.0 gms.		0	0	0	0
15. 2% Free nicotine dust	1.0 oz.		0	0	0	0
16. 2% Free nicotine dust ..	2.0 oz.		10	0	0	0
17. 2% Free nicotine dust	4.0 oz		4	0	0	0
18. Black Arrow dust.	1.0 oz		10	25	17	0
19. Black Arrow dust.	2.0 oz.		1	0	2	0
20. Black Arrow dust	4.0 oz		1	0	1	0
21. Nicofume	1–100	1 hr.	0	39	2	0
22. Nicofume .	1–200	1 hr.	38	105	15	23
23. Nicofume	1–400	1 hr.	37	137	0	49
24. Nicofume	1–100 & soap	1 hr.	1	2	1	0
25. Nicofume	1–200 & soap	1 hr.	0	13	8	22
26. Nicofume	1–400 & soap	1 hr.	7	57	1	43
27. Red Arrow	1–100	1 hr.	0	0	3	0
28. Red Arrow	1–200	1 hr.	2	17	13	1
29. Red Arrow	1–400	1 hr	2	25	0	6
30. Hot water 110–111.5°F		15 min.	1	127	2	162
31. Hot water 110–111.5°F.		30 min.	0	120	1	133
32. Hot water 110–111.5°F.		60 min.	0	47	1	0
34. Bichloride of mercury ..	1–500	1 hr.	2	1	0	0
35. Bichloride of mercury..	1–1000	1 hr.	0	0	0	0
36–37–38 Check......			76	88	187	8

The data show that the fumigation with calcyanide was effective in killing the adults and young thrips but not the eggs. Some control of the egg stage was apparently obtained when 1.5 grams (equals 1.3 pounds per 100 cubic feet) were used. There was considerable loss of gas through the walls of the paper bags as a distinct cyanide odor was noticeable very soon after closing the bags. Very little odor was noticeable when the bags were opened for ventilation after the fumigation periods of 5 hours or 10 hours. There was no injury apparent to the corms. It is realized that the dose used was too large for fumigating large storage chambers where the loss would be much less. If a second treatment had been made after the eggs hatched and before the young had developed to adults, complete control probably would have been obtained.

The carbon bisulphide did not kill either the adults or the young at the dosages used (equals approximately 1 pound and 2 pounds to 100 cubic feet). There was considerable leaking of the gas through the paper bags and very little odor was noticeable when the bags were opened for ventilation after the 5 and 10 hour periods. Carbon bisulphide has been used successfully in fumigating gladiolus corms as well as other corms and bulbs, and successful results would probably have been obtained in this test if a loss of the gas had not occurred through the paper bags. The fumes of carbon bisulphide are explosive and care must be taken in handling the material to see that fire is kept away during the fumigation period.

The paradichlorobenzene used at a rate equivalent to approximately ½, 1 and 2 pounds per 100 cubic feet, was not satisfactory. There was some reduction of thrips at the first examination but apparently no kill of the eggs, as indicated when an examination was made 4 weeks later. Fumes of the paradichlorobenzene were distinct at the first examination but no odor at the second examination. Loss through the paper bags failed to keep a lethal concentration of the gas until the eggs had hatched.

Naphthalene used at the same amount as the paradichlorobenzene was not effective except where the equivalent of 2 pounds to 100 cubic feet of space was used. No naphthalene odor was noticed at the time of the second examination in the bag containing the smaller amount and only a slight odor in the bag containing one gram. A strong odor was present in the bag containing two grams.

The 2% free nicotine dust was effective in all concentrations used. Almost all the thrips were killed at the time of the first examination and no live thrips were found when they were examined 4 weeks later.

Considerable dust was found under shucks surrounding the corms and there was a distinct nicotine odor in the closed bags.

The "Black Arrow" dust (a pyrethrum dusting powder) was effective where the 2 and 4 ounce doses were used, although apparently not as efficient as the nicotine dust. When the nicotine dust and the "Black Arrow" dust was applied to the corms in the bags, they were shaken thoroughly to distribute the dust evenly over the surface of the corms.

"Nicofume" (40% free nicotine) was effective only at a concentration of 1 part to 100 parts of water The addition of ½ of 1% actual soap to the dilution, increased the wetting of the corms and the efficiency of the nicotine, but still left it less. desirable than other materials. "Red Arrow" (a pyrethrum soap spray insecticide) was effective at a dilution of 1–100, and fairly effective at concentrations of 1–200 and 1-400.

Hot water, at a temperature of 110° to 111½° F , was effective in killing the adults and nymphs even when used for 15 minutes. It was only partially effective in killing the eggs when the corms were treated for 1 hour.

Bichloride of mercury used at a dilution of one ounce to 4 gallons (1–500) and 1 ounce to 8 gallons (1–1000) of water was quite effective in killing the adults and nymphs and in preventing reinfestation. This material probably acts as a stomach poison, remaining upon the corms and killing the young thrips after they hatch from the eggs.

The data from the tests indicate and is verified by experience with growers, that several materials or methods might be used successfully. Where one has only a few corms or a large number of varieties in small lots, treatment with naphthalene, paradichlorobenzene, nicotine dust or pyrethrum dust and storing the corms in paper bags or other closed containers should prove very satisfactory. Dipping the corms in bichloride of mercury for 1 hour or as much longer as is necessary to thoroughly wet under the husks is satisfactory. Other mercury compounds have been stated by growers to give good results in thrips control. Fumigation with cyanide or other fumigating material is easy, cheap and effective for larger quantities of bulbs and will give good protection if properly done. It may be necessary to repeat the fumigation in 2 to 3 weeks, depending upon the temperature, to kill the young thrips hatching from the eggs.

Control of the Thrips on the Foliage and Bloom.—The control of the thrips on the foliage and bloom of growing plants is not as easily accomplished as control on the corms. Early egg laying and development of the young occur principally in the sheaths surrounding the stem or in the bloom where they cannot be easily reached with spray materials.

The greenhouse tests were conducted on gladiolus plants growing in 8″ lily pots, 6 plants to a pot. The plants were rather heavily infested at the time the tests were conducted Both treated and untreated plants were kept together on the same bench in the greenhouse. Thus there was opportunity for migration of the adult thrips by flight or by the nymphs crawling from plant to plant

All treatments were made at approximately weekly intervals Counts were made of the total number of adult thrips and of nymphs exposed upon the foliage. These counts varied from one to three day intervals The number of thrips found upon the plants varied considerably, depending upon the particular stage in their life history.

Since the same number of pots were not always used in the different experiments and since some experiments had a number of observations for determining the number of thrips, while other treatments had few observations, the final results have been based upon the average number of thrips found per pot per examination

The spray tests were done at different times during February and March. For the sake of convenience all tests have been included in one table summarizing the results. Only those tests which seemed to show significant results have been given.

TABLE 2. SPRAY TESTS IN CONTROLLING THE GLADIOLUS THRIPS ON THE FOLIAGE OF PLANTS GROWN IN THE GREENHOUSE

Lot No and composition of the spray material	Dilution	No of pots sprayed	No. of times sprayed	No. of times counted	Total No of thrips counted	Average No of thrips per pot per count
16. Black Arrow Insect Dust 40 gms.						
Water 1000 cc		2	3	7	123	10.2
17. Awinc.	1-100	2	3	7	577	48.0
18. Awinc+2% wheat flour.	1-100	2	3	7	516	43.0
19. Derrisol .	1-400	2	3	7	119	9.9
20. Derrisol+2% wheat flour	1 400	2	3	7	93	7.7
Check				1	175	175
21. Tensol 10 cc .	0.5%	4	3	9	335	9.3
B.L. 50 2 cc	1-500					
Liquid lime sulfur 20 cc.	1 50					
Water 970 cc						
22. Tensol (50%) 10 cc	½%	4	3	9	278	7.7
B.L. 50 2 cc .	1-500					
Liquid L. S. 20 cc	1-50					
Lead Arsenate 4 gms	1⅜-50					
Water 978 cc						
23. Derrisol 2½ cc	1-400	4	3	9	727	20.2
Flour 20 gms	1 50					
Lead Arsenate 4 gms	1⅜-50					
24. Derrisol 10 cc ...	1-400	4	3	9	400	11.1
Dry Bordeaux 20 gms.	8-8 50					
Lead Arsenate 4 gms . .	1⅜-50					
Water 980 cc						

TABLE 2. *Concluded*

Lot No. and composition of the spray material	Dilution	No. of pots sprayed	No. of times sprayed	No. of times counted	Total No. of thrips counted	Average No. of thrips per pot per count
25. Tensol 10 cc ..... Dry Bordeaux 20 gms Lead Arsenate 4 gms Water 990 cc	0.5% 8 8-50 1½ 50	4	3	9	1,044	29.0
26. Black Arrow No. 5000 Insect Dust 40 gms Water 1000 cc	1 25	4	3	9	479	13.3
27. Igepon A. P. 5 gms. B. L. 40 2 cc .... Water 998 cc	0.5% 1-500	4	3	9	1,167	32.4
28. Igepon No. 27 5 gms B.L. 40 2 cc . Flour 10 gms Water 998 cc	0.5% 1 500	4	3	9	1,252	34.8
29. Penetrol 5 cc . B.L. 40 2 cc . Water 993 cc	0 5% 1-500	4	3	9	865	24.0
30. Nursery Volck 20 cc . B. L. 40 2 cc Water 978 cc	1 50	4	3	9	698	19.4
31. Wilsonite Dust 40 gms Water 1000 cc	1 25	4	2	8	482	15.0
32. Wilsonite Dust as dust		4	2	8	135	4.2
33. Black Arrow Insect Dust No. 2700 40 gms . . Water 1000 cc	1 25	4	2	8	1,277	39.9
34. Black Arrow Dust No. 2700		4	2	8	220	6.9
35. Lemon Oil Insecticide .	1 16	4	2	8	2,358	117.8
36. NOC (1½% rotenone dust) 40 gms Water 1000 cc	1-25	2	1	8	44	2.7
37. NOC (1½% rotenone) as dust		4	2	8	28	.87
38. Black Arrow Dust No. 5000 as dust . . .		4	2	7	263	9.4
44. NOC Special rotenone dust (1½% rotenone)		4	2	7	30	1.0
45. Hellebore 40 gms. . Water 1000 cc	1-25	4	2	5	48	2.4
46. Hellebore as dust. .		4	2	5	89	4.4
47. NOC special rotenone dust 40 gms. . . . . . . Water 1000 cc	1-25	1	2	5	9	1.8
48. Talc as dust.		4	1	3	123	10.2
49. Rotenone powder 70-72% rotenone 1½ gms. . . . . Talc 70 gms.	1.5% rotenone	4	1	3	212	17.7
50. Rotenone powder 70-72% rotenone 1½ gms. . . Talc 35 gms. . . . . Sulfur 35 gms.	1.5% rotenone	4	1	3	50	4.2
51. 5% rotenone in acetone 10 cc . . . . Talc 90 gms.	1.5% rotenone	4	1	3	6	0.5

Table 2 gives the results of the greenhouse tests in controlling the gladiolus thrips on the foliage.

The average number of thrips per pot per count varied considerably. Most of the liquid sprays containing nicotine, pyrethrum, or rotenone were not very effective in reducing the thrips population. The use of arsenate of lead, or of Bordeaux, or of liquid lime sulfur solution did not increase the efficiency of the sprays. The best results were obtained with dust insecticides applied as dusts or as thin washes of the dust. Wilsonite which contained nicotine, Bordeaux, calcium arsenate and an inert carrier had excellent physical properties. It was observed that fine dust materials acted mechanically in keeping the plants free from thrips as the dust collected on the tarsi of the thrips and they could not keep a foothold.

The dusts containing rotenone were somewhat more effective than the pyrethrum dusts. This may have been partly due to their better physical properties and high rotenone content. Hellebore was very good, especially considering its price as compared with the price of the other dusts. The addition of sulfur to the one rotenone dust apparently increased its efficiency. Field observations have also indicated that sulfur has considerable beneficial results.

In general, the dust materials applied as dusts or as thin washes were more efficient than the usual liquid contact or stomach sprays. This increased efficiency may possibly be partly due to the higher per cent of active principle (such as rotenone, pyrethrins, nicotine, etc.) in the dusts and a greater amount of the insecticide remaining upon the foliage in the dust applications. The amount of active or toxic agents in the dusts varied from one to several hundred times as much as was used in the diluted liquid sprays.

Field Tests in Controlling the Thrips.—The field tests on the gladiolus thrips were directed towards several different things as follows; (1) the development of a dust material which had the best physical properties for use on the gladiolus plants, (2) the development of a dust material which could be applied as a thin wash and which would give good wetting and coverage, (3) the comparison of several different contact sprays.

A number of different kinds of inert dusts were tested as carriers of extracts of rotenone or pyrethrins or used for diluting ground cube root, derris root or pyrethrum flowers. Several samples of a diatomaceous earth were obtained from the Johns Manville Company's plant at Manville. Most of these dusts were very light and fluffy and when mixed with extracts of rotenone or pyrethrins or when diluted with ground

cube or derris roots they gave very light fluffy dusts which dusted beautifully. Unfortunately the dusts would not adhere to gladiolus foliage or in fact to other foliage. The dust particles were so light that they were not deposited on the foliage or were blown off by the force of the dusting in attempting to apply additional dust.

Talc when impregnated with extracts of rotenone or pyrethrins or when mixed with the ground roots was rather heavy for application with hand dusters. It was difficult to obtain an even distribution because of the dust packing and not coming out of the duster evenly. Talc did not adhere well to the foliage after rains.

A dusting clay manufactured by Hammill and Gillespie of New York City had the best properties for dusting and adhering to the foliage. The clay was heavy enough to be applied satisfactorily but did not pack similar to the talc. The clay also wet fairly well with water and proved the most satisfactory inert carrier for use in making materials to be applied as thin washes.

Three of the most satisfactory dust materials were made up as follows:

No. 1. "Inert C" dust	50%
Powdered air floated derris root containing 4% rotenone	25%
Dusting sulfur	25%
No. 2. "Inert C" dust	82½%
Alcoholic extract of pyrethrum flower containing 2.2% pyrethrins	5%
Powdered air floated derris root containing 4% rotenone	12½%
No. 3. "Inert C" dust	67.8%
Powdered air floated derris root containing 4% rotenone	25%
Powdered soap	7.2%

The number 1 dust containing sulfur dusted well and adhered to the foliage reasonably well. The number 2 dust did not dust quite as good as the number 1 dust but would wet with water and wet gladiolus foliage reasonably well. It was used at the rate of 1 pound to 3 gallons of water for a spray. The number 3 dust was applied only as a spray diluted 1 pound to 3 gallons of water. It wet gladiolus foliage well and gave a uniform coating upon drying. Only sufficient soap was added to the dust to produce wetting when used at dilutions of 1 pound to 3 gallons of water. Additional soap caused excessive run off of the spray with a smaller amount of dust on the foliage upon drying.

One pound of dust used as a wet spray covered from 3 to 5 times more gladiolus foliage with better results than did the same amount of dusts.

Several commercial brands of pyrethrum or pyrethrum and rotenone sprays were tested on gladiolus foliage. It was necessary to use most of

these considerably more concentrated than recommended to obtain satisfactory wetting of gladiolus foliage.

The dust materials applied as dusts or as thin washes diluted one pound to 3 gallons of water gave better control of the gladiolus thrips than the liquid contact sprays. The per cent of rotenone or of pyrethrins in the dust materials was considerably greater (from 50 to 100 times) than in the diluted contact sprays This undoubtedly had considerable to do with the better results.

It was observed that field spraying should be started early on young plants and before an infestation was built up if control was to be obtained. Applications should be made at approximately weekly intervals. Materials which gave satisfactory control of the thrips when applied early and regularly, failed to give control when used on infestations where the thrips were abundant and severe injury was beginning.

MR. FRIEND: I should like to ask how much Paris green and brown sugar is used?

MR. H. H. RICHARDSON: The formula is Paris green one ounce, brown sugar two pounds, and water to make three gallons.

MR. J. A. MANTER: I should like to ask about how much naphthalene flakes should be used in a five-pound bag, nearly full of corms.

MR. HAMILTON. We have been recommending around an ounce to 150 corms.

MR. WEIGEL: In the paper, I gave results. A check-up we made among growers in quite widely separated areas in New York State, and also around Washington, proved naphthalene, one ounce to one hundred, the best. Scatter it among the corms after they are sufficiently cured, not earlier than a month after they are brought in from the field and preferably by midwinter. Cyanide fumigation also was successful, but if the interval was not definitely observed, they would not get complete control

As Mr. Smith pointed out, with the carbon tetrachloride, that also has the advantage of killing all stages at one treatment. However, the growers are rather lax in observing the necessary precautions in over dosage and also over exposure.

MR. CUTRIGHT: In reference to the use of naphthalene in corms stored in fruit cellars, in Ohio it is customary for a number of people to store corms with the various other lots they may have, fruit, and so on. We all know that apples will take on a decided flavor which renders

them very unpalatable if placed close to naphthalene. That must be taken into account.

MR. SMITH: A precaution should be mentioned, because naphthalene will injure the growing rootlets or sprouts So the treatment should be applied before growth has broken the dormant period. Also, if at the time of planting any flakes are left among corms, these should be shaken out.

MR. HUTSON: I should like to ask Mr. Smith in regard to his one treatment with semesan. There is semesan this and semesan that. Was there any qualification of that semesan?

MR. SMITH: This material contained 30 per cent of the active ingredient.

MR. HAMILTON: Mr. White, in the experiment station in New Jersey, has done considerable work with other mercury compounds from the standpoint of control of disease, and his general observations have been that a number of those are also effective in controlling thrips. It was not done as experimental work from that standpoint, but he believes they are just as good possibly as mercury and semesan and some of them, he says, may be better for fungus growths.

We tested out two others, calomel and semesan. These are recommended, we are told, by the Bureau of Plant Industry as dips for five to ten minutes; used at these exposures, they were not effective against thrips. With longer exposures there was satisfactory control.

MR. HUTSON: I have some data, similar to that Mr. Hamilton gave, using it for disease control on gladioli corms, and getting rid of the thrips. The work was not done in an experimental way, but it would seem to indicate the material might be used.

Friday Evening, December 30, 1932

COMPATIBILITY OF OIL EMULSION-CRESYLIC ACID SPRAYS WITH FUNGICIDES[1]

By JOSEPH M. GINSBURG, Ph.D., *Biochemist in Entomology, New Jersey Agricultural Experiment Station*

ABSTRACT

Laboratory tests have shown that stable spray mixtures can be prepared from oil emulsions containing cresylic acid with either freshly prepared Bordeaux or lime sulfur containing organic colloids. Orchard experiments on five blocks of apple trees have shown that the addition of fungicides do not in any way interfere with the toxicity of either oil emulsion to red mite eggs or of cresylic acid to aphis eggs.

The purpose of the experiments presented in this paper was two fold: First, to adjust the oil emulsion-cresylic acid spray so as to make it compatible with either Bordeaux or lime sulfur; Second, to determine whether the admixture of the above fungicide will in any way affect the toxicity of either the oil to red mite eggs or the cresylic acid to aphis eggs.

REVIEW.—During the last three years the combination of oil emulsions with cresylic acid has been extensively applied by orchardists in New Jersey as a delayed dormant spray to control scale, red mite, and aphis on apple trees. It has been shown that (1) the cresylic acid in this mixture compares well with nicotine in its efficiency to control aphis and does not in any way interfere with the toxicity of the oil to scale and red mite eggs. This spray was first recommended by Dr. Headlee as a result of laboratory and orchard experiments conducted (1, 2) in 1927 and 1928, on apple trees. The practical advantage to the farmer in using this spray mixture in preference to nicotine is an actual saving of money.

It should be noted here that, cresylic acid is merely a trade name to designate a mixture of certain acidic coal tar distillates which usually contain phenol, cresols, xylenols, and other acidic groups of still higher boiling points. There are several commercial grades of cresylic acid on the market in which the proportions of the above constituents vary considerably. In our experiments we found that 0.5% cresylic acid of the following specifications was efficient in killing aphis eggs when combined with oil emulsion containing 3% actual oil and caused no appreciable injury to peach and apple buds in the delayed dormant stage:

Boiling range..................................	205 – 240°C.
Xylenols..	60 – 70%

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

Cresols	15 – 25%
Acids of higher boiling points	5 – 25%
Phenol	none or a trace

Ever since the cresylic acid-oil spray assumed commercial importance, the problem of incorporating a suitable fungicide confronted us. Such a combination would give protection from scale, aphis, red mite, and scab in one application, thus still further reducing the spray cost. While miscible with oil in all proportions, cresylic acid does not mix readily with either lime sulfur or with commercial Bordeaux, unless coated with protective colloids.

During the early spring of 1930 experiments were carried out in a commercial orchard (3) with oil soluble copper oleate as a possible fungicide. The compound was dissolved in the oil and then emulsified with soap. The resultant emulsion mixed readily with cresylic acid, but the fungicidal value of copper oleate proved inferior to either lime sulfur or Bordeaux. The tests with the above fungicide against apple scab were carried out by Dr. W. Martin, Plant Pathologist and Dr. A. C. Sessions.

Laboratory and field experiments conducted in a preliminary way during 1931 (4) have shown that:

1. Either copper ammonium silicate (prepared by Dr. Sessions) or commercial Bordeaux containing 10% bone-glue mixes readily with cresylic acid.

2. Colloidal cresylic acid (prepared by incorporating 10 to 20% soap) produces a more stable mixture with either the oil emulsion alone or with the oil emulsion containing the copper fungicide.

3. The above combinations did not reduce the toxicity of the oil to red mite eggs, nor the toxicity of cresylic to aphis eggs.

Experimental.—During the spring of 1932 experiments were conducted in the college apple orchard with cresylic-acid-oil-emulsion sprays to which either lime-sulfur or home-made Bordeaux was added. Previous to the field experiments, various mixtures of oil, cresylic, Bordeaux, and lime sulfur were tested in the laboratory. The results presented in Table 1, show that freshly prepared Bordeaux of 4–6–50 formula, unlike the commercial powdered Bordeaux, mixes without any difficulty with oil emulsions containing cresylic acid and leaves no objectionable residue in the spray tank. On the other hand, lime sulfur forms flocculent precipitates with cresylic or with oil emulsions containing soap emulsifiers, when used either separate or combined, due to the formation of insoluble calcium salts. The flocculation was eliminated when the lime sulfur was mixed with powdered skim milk, 3 pounds to

100 gallons, and colloidal cresylic acid instead of the ordinary 95% cresylic was used.

FIELD EXPERIMENTS. -In order to study the effect of either lime sulfur or Bordeaux on the toxicity of the oil-cresylic acid mixture in the field, 5 blocks of apple trees in the college farm, heavily infested with overwintered eggs of aphis and red mite were sprayed as enumerated in Table 2. Each block contained six trees including the following varieties: Grimes, Stayman, Wealthy, and Paragon.

The following procedure was used in preparing the sprays in 100 gallon tank capacity.

TABLE 1. LABORATORY TESTS WITH OIL EMULSIONS, CRESYLIC ACID AND EITHER LIME SULFUR OR HOME-MADE BORDEAUX

Test No.	Composition of Spray Mixture	Stability of mixture
1.	Bordeaux 4-6-50 Cresylic 0.5% Oil 3.0% (soap emulsifier)	Good
2.	Bordeaux 4-6-50 Cresylic 0.5% Oil 3.0% (ammonium caseinate emulsifier)	Good
3.	Lime sulfur 1:9 Cresylic 0.5% Oil 3.0%	Breaks up
4	Lime sulfur 1:9 Cresylic 0.5% Oil 3.0% Skim milk 3 lbs. to 100 gallons	Breaks up
5.	Lime sulfur 1:9 Colloidal cresylic 0.5% Oil 3.0%	Breaks up
6.	Lime sulfur 1:9 Colloidal cresylic 0.5% Oil 3.0% Skim milk 3 lbs. to 100 gallons	Good
7.	Lime sulfur 1:40 Cresylic 0.5% Oil 3.0%	Breaks up
8.	Lime sulfur 1:40 Cresylic 0.5% Oil 3.0% Skim milk 3 lbs. to 100 gallons	Breaks up
9.	Lime sulfur 1:40 Colloidal cresylic 0.5% Oil 3.0%	Breaks up
10.	Lime sulfur 1:40 Colloidal cresylic 0.5% Oil 3.0% Skim milk 3 lbs. to 100 gallons	Good

1. *Bordeaux Spray.* As soon as the water and agitator were started in the tank, about 8 pounds of copper sulfate (Snow) were added. When the tank was about 2/3 full and most of the copper sulfate dissolved, 12 pounds of hydrated lime were sifted in. While the agitator continued to run, oil emulsion, enough to make up 3% actual oil, was mixed in. The cresylic acid was added last The rest of the water to make up 100 gallons was then run in.

2. *Lime Sulfur Spray.* When the tank was about half full with water the agitator was started. About three pounds of powdered skim milk (first made into a thin paste with a small amount of water in a separate container) were added. The concentrated lime sulfur was then added. When the mixture of skim milk and lime sulfur became uniform the oil emulsion and finally the colloidal cresylic acid were mixed in. The water was then allowed to fill up the tank to 100 gallons. Two strengths (1:9 and 1.40) of lime sulfur were used. While the lower concentration is sufficiently strong as a fungicide and is usually recommended for special scab spray, it was considered advisable also to test the winter concentration of lime sulfur, the highest strength the apple trees can stand without severe injury in the delayed dormant stage.

Two types of commercial oil emulsions were used with the Bordeaux spray. One contained soap emulsifier, obtained from Mechling Bros Chemical Company, Camden, N. J., while the second, contained ammonium caseinate emulsifier obtained from Sherwin-Williams, Bound Brook, N. J. The colloidal cresylic acid was prepared by incorporating about 20% soap in the ordinary 95% cresylic acid. The skim milk was produced by the "Spray" process and readily dissolved in cold water.

Several days before the sprays were applied, a total of 560 twigs, collected from every tree in the blocks were examined for red mite and aphis eggs. About 504 twigs had red mite eggs ranging from a few to too numerous to count, while 254 twigs had aphis eggs ranging from 1 to 4 per twig. These observations indicate that out of every 100 twigs 90 contained red mite eggs and 45 contained aphis eggs suggesting approximate infestation of 90% and 45% for the two insects respectively. The sprays on the five blocks were applied on April 16 and counts of hatched aphis and red mite were made by Mr. C. Ilg (laboratory Assistant) on May 9 and May 16 when the leaves were from ½ to 1 inch out. A total of 100 fruit spurs per block, collected at random, from every tree were examined each time. Since it was not practical to leave a block of trees entirely unsprayed to serve as checks, about 200 twigs containing both, red mite and aphis eggs were placed in jars of water and kept in the

greenhouse until the leaves were about half an inch out. Counts of live aphis and red mite were then made on 100 fruit spurs.

The results tabulated in Table 2, show that the highest number of live aphis in any one of the blocks was five, while the highest number of live red mites was only 3 per 100 fruit spurs. Keeping in mind the large abundance of both aphis and mite eggs present on the twigs, the writer considers this as very good control No appreciable differences in control are observed between the five different spray combinations tested. When compared with block 5 where no fungicide was used, it becomes evident that neither the home-made Bordeaux nor the lime sulfur has in any way reduced the toxicity of either cresylic acid to aphis eggs or the oil to red mite eggs.

TABLE 2. FIELD TESTS WITH OIL-CRESYLIC SPRAYS CONTAINING EITHER HOME-MADE BORDEAUX OR LIME SULFUR

Block No.	Composition of spray	Date sprayed	Examined 5/9 No. of live Aphis per 100 spurs	No. of live Red Mite per 100 spurs	Examined 5/16 No. of live Aphis per 100 spurs	No. of live Red Mite per 100 spurs
1	Bordeaux 4–6–50 .... Cresylic 0.5% Oil 3.0% (Soap Emulsifier)	4/16	3	0	5	1
2	Bordeaux 4–6–50 .... Cresylic 0.5% Oil 3.0% (Ammonium caseinate emulsifier)	4/16	2	1	3	0
3	Lime sulfur 1:40 .... Colloidal cresylic 0.5% Oil 3.0% Skim milk in 100 gals. 3 lbs.	4/16	3	1	5	3
4	Lime sulfur 1:9 .... Colloidal cresylic 0.5% Oil 3.0% Skim milk in 100 gallons. 3 lbs.	4/16	4	0	2	1
5	Cresylic 0.5% .... Oil 3.0% (Soap emulsifier)	4/16	3	1	4	3
Check	Untreated apple twigs kept in the greenhouse		62	281	–	–

SUMMARY AND CONCLUSIONS.—Laboratory tests with oil-emulsion-cresylic-acid spray mixtures were carried out with the purpose of improving their stability with fungicides such as Bordeaux and lime sulfur. Following the laboratory tests, field experiments were conducted on

five blocks of apple trees with as many selected spray mixtures in order to determine whether the addition of fungicides to an oil cresylic spray will in any way affect its toxicity to the eggs of either aphis or red mite.

The laboratory results have shown that:

1. Freshly prepared Bordeaux of 4–6–50 formula produces a stable mixture with oil emulsions containing 0.5% cresylic acid.

2. Lime sulfur is not compatible with oil emulsions containing cresylic acid.

3. When treated with powdered skim milk or similar colloids, lime sulfur forms stable spray mixtures with 0.5% colloidal cresylic acid.

The field experiments have shown that:

1. Incorporating either Bordeaux or lime sulfur in oil-cresylic sprays did not decrease their toxicity to eggs of aphis and red mite.

2. Combining oil-cresylic sprays with either "home-made" Bordeaux or lime sulfur in order to control scale, aphis, red mite and fungous diseases is practical and economical.

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Mr. C. H. Richardson: I should like to ask whether this can be used in mid-summer on trees and foliage?

Mr. Ginsburg: I should say it cannot be used because we have two per cent oil. The oil by itself will cause injury. Half of one per cent cresylic acid, and the combination of the two will cause injury. It is used primarily as a delayed dormant spray applied when the leaves are just coming out, the size of squirrel ears.

President Flint: I should like to ask Mr. Ginsburg if he ever used this combination on peach. We have many orchards planted with peach and apple.

MR. GINSBURG: I have used a combination of oil emulsion and cresylic acid on peach, even at the high concentration indicated in this paper, namely, one per cent cresylic acid, with no injury, at the same time of the year. I concluded that the peach tree in the dormant stage can stand oil and cresylic acid better than the apple. I have not used it on the peach, but I think there would not be injury from the addition of lime sulfur.

PRESIDENT FLINT: At the time you would be using that for aphis on the apple, the peach trees would be further advanced, very likely in bloom. Do you think it would be injurious at that time?

MR. GINSBURG: I have used it at the stage when the peach bud is turning red. I killed red mite on peaches with this spray, without any injury, whatsoever.

MR. HEADLEE: I think it is essential, in speaking of the delayed dormant spray, to point out that this delayed dormant spray period is not the same as the delayed dormant spray period in New York State.

This period begins when the bud scales of the fruit buds begin to separate and show the silvery lines on the buds and closes before the little leaves stick up.

ARSENICAL RESIDUES FOUND ON APPLES IN THE PACIFIC NORTHWEST THROUGHOUT A SEASON OF TYPICAL SPRAYING WITH LEAD ARSENATE[1]

By R. H. CARTER, *Bureau of Chemistry and Soils* and E. J. NEWCOMER, *Bureau of Entomology*

ABSTRACT

Samples of apples from trees which had been sprayed throughout the season with lead arsenate were selected before and after each spray and at harvest time and analyzed for arsenical residue. A fairly uniform minimum coating of about .006 mg./sq. cm. was found to have been maintained during the season by spraying about every ten days when growth was rapid, and every two or three weeks later on. This coating was increased to about .012 mg./sq. cm. by each of the various applications, resulting in an average coating of about 0.10 mg./sq. cm. The relationship between the residue results calculated as grains per pound and as milligrams per square centimeter is discussed. The percentages of the total accumulated residue at harvest time put on by each spray is indicated.

Pure food regulations place a maximum limit on the quantity of arsenic allowed on apples when they are marketed, while effective con-

[1]Presented at the Forty-Fifth Annual Meeting of the American Association of Economic Entomologists, Atlantic City, N. J., December 28 to 31, 1932.

trol of the codling moth sets a minimum limit on the deposit carried by the fruit during the growing season. Since the legal limit is stated in terms of weight of residue per pound, and control experiments can best be discussed in terms of weight per unit area of fruit, a study of arsenical residues on apples must include a consideration of the relation of deposit to both weight and surface area, and the constantly changing relationship of these two measures caused by the growth of the fruit

The relation of weight of deposit to weight of apple is easily determined, but the relation to surface area is not so simple. The writers have examined several methods of determining the area of apples. Barnes (1) has described an apple as a cardioid and has given a formula for the calculation of the surface area on this basis Magness et al. (2) have assumed an apple to be a sphere, and it may also be considered as an oblate spheroid Markley and Sando (3) in determining the quantity of wax on apples, have used disks cut from the surface, and have given a formula for the determination of the area of the disks. The writers have calculated the surface area of apples from weight according to these three assumptions of shape, (with further plausible assumptions concerning eccentricity in the case of the spheroid) and have found the results to be within two or three per cent of each other. They have also found that the result for residue per unit of surface area is practically the same whether calculated on the basis of these assumptions or from the analysis of disks cut from the surface.

For the purposes of this investigation, therefore, the simplest method has been used, that of determining the residue on entire apples and of calculating surface area from weight by assuming that the apples are spheres and have uniform known density.

By submerging Winesap apples in water it was found that they displaced about 1.2 cc. per gram and that this relationship did not vary greatly during the season. The surface area (S.A.) was therefore obtained by using the formula S. A. $= 4.84 \left[\sqrt[3]{(\text{wt.} \times 1.2)}\right]^2$. A spray schedule was chosen for this investigation that is fairly typical of those used in the Pacific Northwest (Table 1). The first four cover sprays were applied during the occurrence of the first brood of the codling moth, and the fifth and sixth cover sprays during the second brood. Samples, each consisting of 10 to 50 apples, were obtained from the orchard before and after each cover spray, and at harvest time. The arsenical deposit was removed by the ordinary rapid solvent method, and arsenic determined by the Gutzeit method. The average weight of the apples in each sample was found and from it the area was calculated. The quantity of arsenic was calculated in terms of grains of As_2O_3 per pound of

fruit, milligrams per apple, and milligrams per square centimeter of surface. These data are given in Table 2. This has been repeated, at least for a portion of the season, for several years, but as the results are in

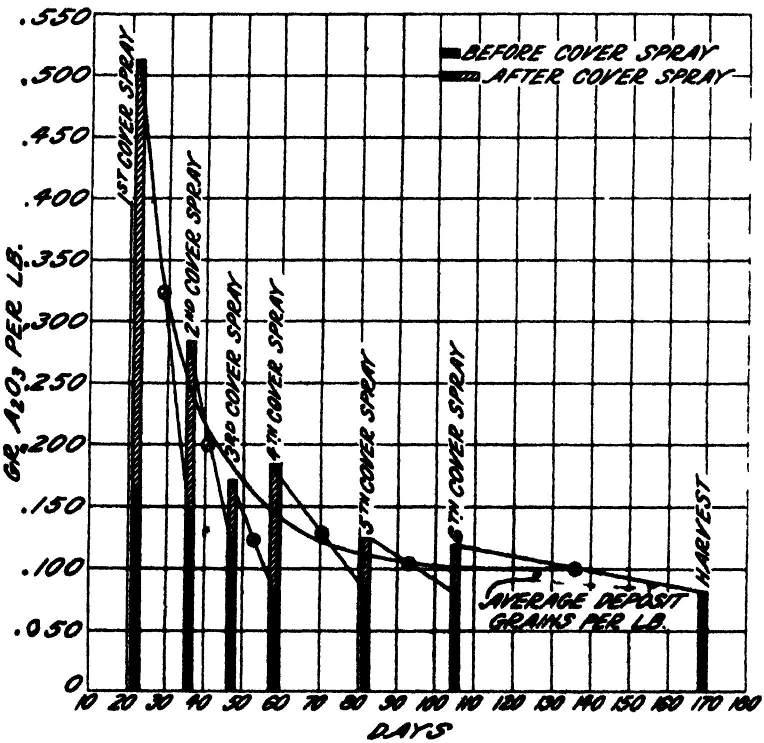

FIG 42. Arsenical residues per pound of apples before and after each cover spray and at harvest.

substantial agreement, only the figures for 1930 are given. The result obtained after the first cover spray is abnormally high, because the lead arsenate was used 50 per cent stronger than in the other applications. Normally, this deposit should have been about .333 grain per pound.

In spite of random sampling, there are some variations in the results, but the important relationships between deposit and growth of fruit are shown.

Considering first the deposit per pound of fruit, Figure 42 shows that this is high early in the season when the fruit is small and later on becomes less. On the other hand Figure 43 shows that the surface density of deposit fluctuates about a nearly constant figure. This difference is of course due largely to the fact that the weight and surface area

of a sphere do not increase proportionately, the weight increasing the more rapidly. In order to show this, the relationship of surface area to weight and growth curves based on each of these magnitudes are given

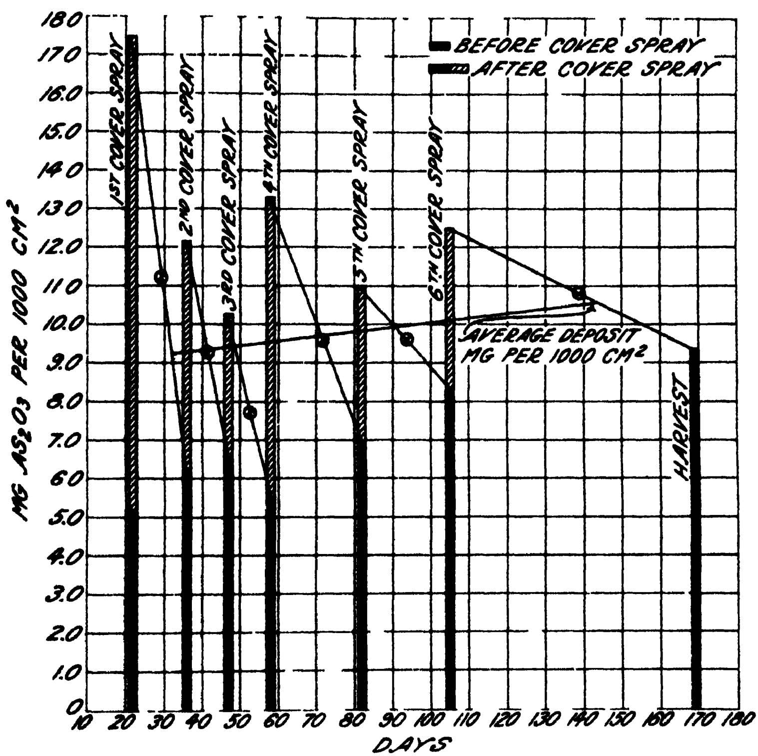

FIG. 43. -Arsenical residues per thousand square centimeters of apple surface before and after each cover spray and at harvest.

in Figure 44. At the time of the earlier sprays, the apples had a surface area, in square centimeters, many times their weight in pounds and this ratio continuously decreased throughout the season as is shown in Figure 44.

Since the apples have little area early in the season, the percentage of the final residue resulting from the earlier sprays is relatively small. This is shown in Table 3, the quantity of As_2O_3 placed on the fruit by each application, in terms of milligrams per apple, having been derived from the data in Table 2, and the grains per pound figured from this, using the average weight at the time of each application. The percentages of the final residue are figured in the same manner, using the average weight of .221 lbs. at harvest, and are shown graphically in

Figure 45. The first four cover applications, which are those made for the first brood of the codling moth, put on only about 40 per cent of the total residue, and the first three cover applications did not put on more than 20 per cent of the total.

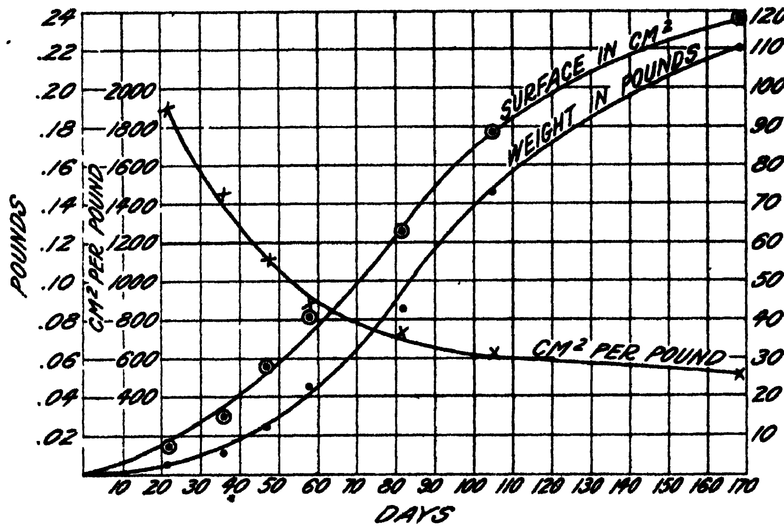

FIG. 44.—Relation of surface area to weight of apples during growing season.

The control of the codling moth is dependent not so much on the total deposit of lead arsenate as on the distribution of that deposit over

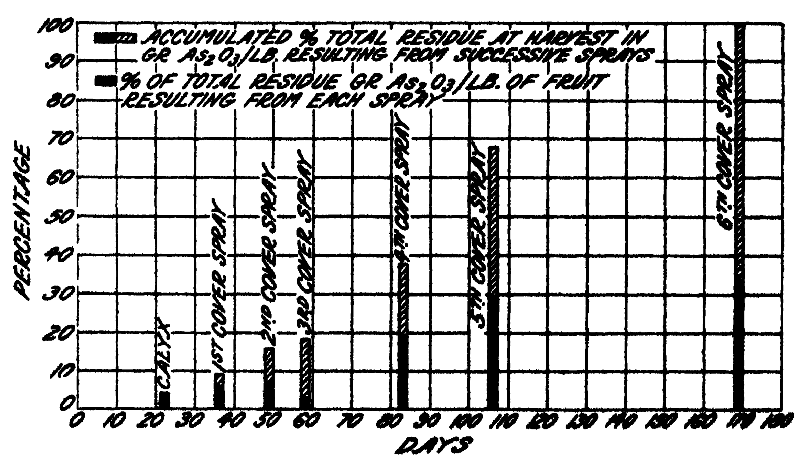

FIG. 45.—Percentage of final spray residues resulting from each application of spray.

the period when the larvae are active. If possible, the applications should be timed with respect to weather conditions and the hatching of the eggs in such a manner as to have the heaviest deposit on the fruit when the largest number of larvae are hatching. In the schedule upon which these studies are based, for example, there was a relatively long interval between the first and second cover sprays because the weather was cold and there were few eggs hatching at that time The interval between fourth and fifth sprays was long as it came between the first and second broods, and few eggs were hatching. During the time the second brood was active (July 15 to September) the fruit was growing more slowly, and there was little loss of deposit by weathering, hence it was unnecessary to spray as often as during May and June It should be understood that the results obtained from these studies are dependent on the climatological and horticultural conditions surrounding the experiments. Therefore, it cannot be assumed that the same results would be obtained in other seasons or in other localities, but they are at least indicative of what to expect. The distribution may be judged by means of the deposit per square centimeter of surface at various times during the season, as shown in Figure 43. The spray schedule used in these experiments maintained a minimum coating of about 006 mg./sq. cm., and this coating was increased to about 012 mg sq cm. by each of the various applications, resulting in an average coating of about .010 mg./sq. cm. It is obviously impossible to maintain a uniform coating at all times. The very rapid growth early in the season, as shown in Figure 44, results in a rapid thinning of the deposit, and it is necessary, in heavily infested orchards, to spray about every ten days during the activity of the first brood, as was done in this case, and very often it is also necessary to add oil emulsion to the spray or to use more lead arsenate.

The schedule used controlled the worms quite well but resulted in a rather high residue at picking time. This deposit compares favorably with that found in other sprayed orchards as Spuler and Dean (1) have stated that, in orchards in the Wenatchee District receiving six cover sprays, a deposit of 75 micrograms per square inch of surface was found ten days after the last spray. This is equivalent to slightly less than 0.012 mg./sq. cm., which is about what was left with our schedule ten days after the last application. It cannot be assumed that such a deposit will always control, as these authors have further stated that the type of deposit is also important. Figure 46 has been constructed for those who desire to focus their attention upon the surface density of

deposit, rather than upon the customary value of grains As_2O_3 per pound. It gives the factor by which grains per pound should be multiplied to obtain milligrams per square centimeter. The factor is of course dependent upon the average weight of single apples and is based upon

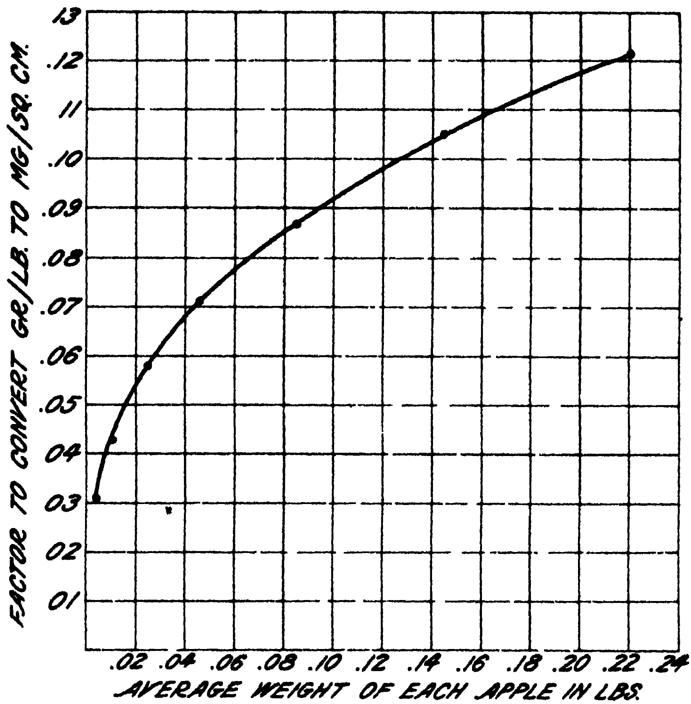

FIG. 46. -Factors for converting grains per pound into milligrams per square centimeter.

the assumptions previously made, that apples are spheres and have a density of 0.83 grams per cc.

CONCLUSIONS.—It is evident from these studies that the major part of the spray residues on harvested fruit is due to the late applications. This is important, as it indicates at once that substitutes for lead arsenate are of much greater value in the late sprays than in the early sprays. By using such substitutes in only the last two applications of the particular schedule under consideration 60 per cent of the final arsenical residue could be avoided, with a consequent simplification of residue removal.

These studies also show that under the conditions of the experiment spraying should be done about every ten days during May and June,

when the first brood of the codling moth is active, in order to maintain a fairly heavy coating, as there is a rapid loss on account of weathering and growth of the apples.

It is also evident that the figures representing grains of arsenical residue per pound tend to decrease throughout the season while the figures for mg. per sq. cm. of surface area tend to remain constant or to increase. This is due to the different rates of increase of weight and surface area.

TABLE 1. SPRAY SCHEDULE USED IN DETERMINING ARSENICAL RESIDUES

Application	Date	Treatment
Calyx	May 1	Lead arsenate, 3 lbs. to 100 gals.
First cover	May 22	Lead arsenate, 3 lbs. to 100 gals.
Second cover	June 4	Lead arsenate, 2 lbs. to 100 gals., and emulsified oil, ¾%
Third cover	June 15	Lead arsenate, 2 lbs. to 100 gals.
Fourth cover	June 26	Lead arsenate, 2 lbs. to 100 gals.
Fifth cover	July 20	Lead arsenate, 2 lbs. to 100 gals., and emulsified oil, ¾%
Sixth cover	Aug. 12	Lead arsenate, 2 lbs. to 100 gals.
Harvest	Oct. 15	

TABLE 2. DEPOSIT OF ARSENICAL RESIDUE FOUND ON APPLES BEFORE AND AFTER EACH COVER SPRAY AND AT HARVEST

Time of sampling in relation to cover sprays	No. apples	Av. wt. lbs.	Av. wt. grams	Av. area sq. cm.	Deposit of As_2O_3 grains/lb.	Deposit of As_2O_3 mg./apple	Deposit of As_2O_3 mg./sq. cm.
Before 1st	50	.003	1.4	6.1	.160	.032	.0052
After 1st	50	.005	2.2	9.2	.509	.160	.0174
Before 2nd	50	.011	5.0	15.9	.134	.094	.0059
After 2nd	50	.010	4.5	14.9	.280	.180	.0120
Before 3rd	50	.023	10.6	26.4	.115	.174	.0065
After 3rd	50	.027	12.4	29.3	.169	.300	.0102
Before 4th	50	.042	18.8	38.8	.078	.210	.0054
After 4th	25	.050	22.4	43.4	.181	.580	.0133
Before 5th	20	.081	36.5	60.1	.081	.425	.0071
After 5th	20	.092	41.5	65.5	.123	.725	.0110
Before 6th	20	.148	67.0	90.2	.078	.750	.0083
After 6th	10	.142	64.5	87.9	.119	1.100	.0125
Harvest	18	.221	100.0	117.8	.0775	1.112	.0094

TABLE 3

	Gain in gr./lb. harvested weight	Amount put on / Amount found
From calyx	.0022	2.8%
From 1st cover spray	.0046	6.1
From 2d cover spray	.0055	7.1
From 3rd cover spray	.0025	3.2
From 4th cover spray	.0150	19.3
From 5th cover spray	.0226	29.1
From 6th cover spray	.0251	32.4
Harvest	.0775	100.0%

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A METHOD OF RAPIDLY APPLYING LIQUID SOIL INSECTICIDES[1]

By J. M. MERRITT, C. B. DIBBLE, O. E. ROBEY, *East Lansing, Michigan*

ABSTRACT

Economical application of large quantities of dilute soil insecticides by means of a porous hose, the dilution of the active ingredient being effected by pumping into the water supply Other applications for the method are suggested

Control of a soil-inhabiting pest, undertaken during the past summer, necessitated treating a considerable area with carbon disulphide emulsion as recommended for the control of the Japanese beetle (1)[2]. Distribution of the material through an aspirator type of proportioning machine having a possible capacity of 250 square feet per hour actually resulted in the treatment of about 100 square feet per hour. The operation of the machine required one man, who directed the distribution of the emulsion through a single nozzle.

The situation required the even distribution of the emulsion over a larger area in order to increase the area treated per man hour. This was accomplished by pumping the miscible carbon disulphide solution at a definite rate into the water supply, thus obtaining the proper emulsion, which was subsequently distributed over several hundred square feet simultaneously through a porous hose, such as is used at this Station for irrigation purposes (2).

The water was supplied by a centrifugal pump through a two-inch pipe line, Venturi meter measurements showed that this pump was capable of delivering 120 gallons per minute with ten pounds pressure at the end of the pipe line. The injection of the solution into the pipe

[1]Work done by C. B. Dibble and J. M. Merritt, Section of Entomology, in collaboration with O. E. Robey, Section of Agricultural Engineering, Michigan State College.—Jour. Article No. 135 (n. s.) from Mich., the Mich. Agr. Expt. Sta.

[2]Reference is made by number to "Literature Cited."

line was accomplished by means of a small reciprocating force pump. The pump was made of bronze and fitted with two cylinders: bore 5/8 of an inch, stroke ½ inch The pump, operated by a ¼ horse-power electric motor at 126 r.p.m., had a capacity of 500 cc per minute. The flow of solution from the pump was governed by a pressure relief valve and a metering valve, protected against clogging by a 60-mesh screen. The resulting emulsion was distributed through unsized canvas hose made of 12-ounce duck, 2½ inches in diameter. When filled with water at ten pounds pressure, 12½ gallons seep uniformly through the pores of the fabric per 100 feet of hose per minute

In testing this apparatus a single 200-foot length of porous hose was used, and the flow of water was regulated and maintained at 25 gallons per minute and ten pounds pressure, by using two gate valves, a meter, and a pressure gauge in the pipe line. In order to meet the requirements of the recommendations for the application at a soil temperature of 50–60 degrees F., 57 cc. of solution must be added to every ten gallons of water and applied at the rate of 2.5 gallons per square foot of soil treated. This was accomplished by injecting the solution into the pipe line at a pressure of seventeen pounds on the pump gauge, maintained by regulation of the relief valve The flow was governed by a metering valve, previously calibrated by drawing the solution from a graduated container and timing with a stop watch

The uniformity of the resulting emulsion was determined by collecting samples at 20-foot intervals along the hose. These were placed in tight containers, and subsequently tested for carbon disulphide content through the courtesy of Dr. E. J Miller, of the Michigan State College Agricultural Experiment Station, Chemical Section The tests indicated a uniform concentration of carbon disulphide throughout the length of the hose.

The characteristics of the application of water to the soil by means of a porous canvas hose have been previously determined through its use in irrigation. It has been found that the distribution along the hose line is comparatively uniform over considerable variations in elevation and soil conditions. Sidewise from the hose line, the distribution is usually uniform from two to four feet. Since irrigation water applied to a properly-drained soil quickly adjusts itself by raising the moisture to its field capacity (3), excessive concentration of the emulsion is not probable.

By this method it is possible to apply carbon disulphide emulsion at the rate of 2½ gallons per square foot to an area of 600 square feet per hour of actual operation, using one 200-foot length of porous hose At 50–60 degrees F., soil temperature, this requires 142.5 cc. of solution and

25 gallons of water per minute. It is possible with the equipment described to increase the number of lines of hose and treat a larger area at one time, without changing the proportions, and it is also possible to change the proportions to meet different requirements.

The cost of application is lower than any which has come to our attention. The pump, relief valve, and the metering valve were designed and constructed by the authors at a nominal cost. Canvas hose can be made at present for about four cents per linear foot. Therefore, the apparatus was assembled with comparatively little expense.

This preliminary work would indicate that it is entirely possible to efficiently and economically treat large areas of soil with liquid insecticides, fungicides, and soluble fertilizers by introducing the active ingredient into the water supply in the proper dilution and to distribute it through a porous hose. The utilization of any one of several types of injecting devices is possible. The essential requirements are a fairly uniform water supply and an accurate metering valve to control the injection. The balance between the water supply and the solution must be maintained within a small margin to insure a uniform distribution of the active ingredient. The flexibility in the capacity of the injection apparatus permits the simultaneous treatment of larger areas than those mentioned. In fact, if the water supply is available, data obtained by this Station in using the hose in irrigation shows that one man can handle 1000 feet of hose, treating soil at the rate of 160 gallons per minute.

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A VISIT TO PYRETHRUM FIELDS OF DALMATIA

By Albert Hartzell

Abstract

An account is given of a visit made in August, 1932, to Dalmatia and the pyrethrum industry of that country is briefly described. Proposed measures to improve the quality of the product are reviewed.

A desire to obtain first hand information regarding the production of pyrethrum, now so generally used as an insecticide, was the motive that induced the writer to visit Dalmatia. Unfortunately only a short time could be devoted to this trip as the occasion for being in Europe was to attend the Fifth International Congress of Entomology at Paris. Leaving Venice on August 9, it was a 6 hours' ride by rail to Fiume on the eastern shore of the Adriatic Sea. The Rečina River, a tiny stream, forms the Italian-Yugoslav boundary between Fiume, formerly a free state but now under Italian control, and Sušak. Upon arrival in Sušak we presented our letter of introduction to "Putnik," the government travel and trade bureau, from its New York Office. As very little pyrethrum is grown in this vicinity arrangement was made to go by steamer to Split, in Dalmatia, with Mr. Stephan Čečuk, government agricultural agent, in charge of pyrethrum production and control.

The east coast of the Adriatic is deeply indented with estuaries and there are numerous islands. As the weather was favorable the steamer threaded its course in the quiet blue water within sight of the summit of the mountains along the coast The colorful but barren waste of the mountains and the almost oriental atmosphere of the ports of call made us aware that we were approaching the gateway of the East.

Dalmatia is no longer a political unit but the name is applied to the greater part of the coast of Yugoslavia. It is a narrow strip of country approximately 200 miles long, 35 miles wide at the north, and tapering to a point at the south. It comprises roughly the Adriatic water-shed and as the Dinaric Alps are near the sea it gives the country its shoe-string shape. In area it is nearly the same size as Connecticut. The average temperature is from 57° to 63° F. The rainfall varies, being heaviest in the south, but in the region where most of the pyrethrum is grown the annual precipitation averages about 30 inches, confined chiefly to the fall and spring. The summers are hot and dry and there is an abundance of sunshine. The great mass of the people speak Serbo-Croat but we found little difficulty in making ourselves understood with German. The people are tall and are said to be descendants of the ancient Illyrians with Avar and Slav mixture. The eastern Adriatic has been held suc-

cessively by Rome, Venice, Turkey, Italy, Austria, and finally since 1918 by Yogoslavia The frequent political changes have retarded its progress agriculturally. Practically all the familiar place names have been changed and Slavonic ones substituted. On the map (Fig. 47) the names

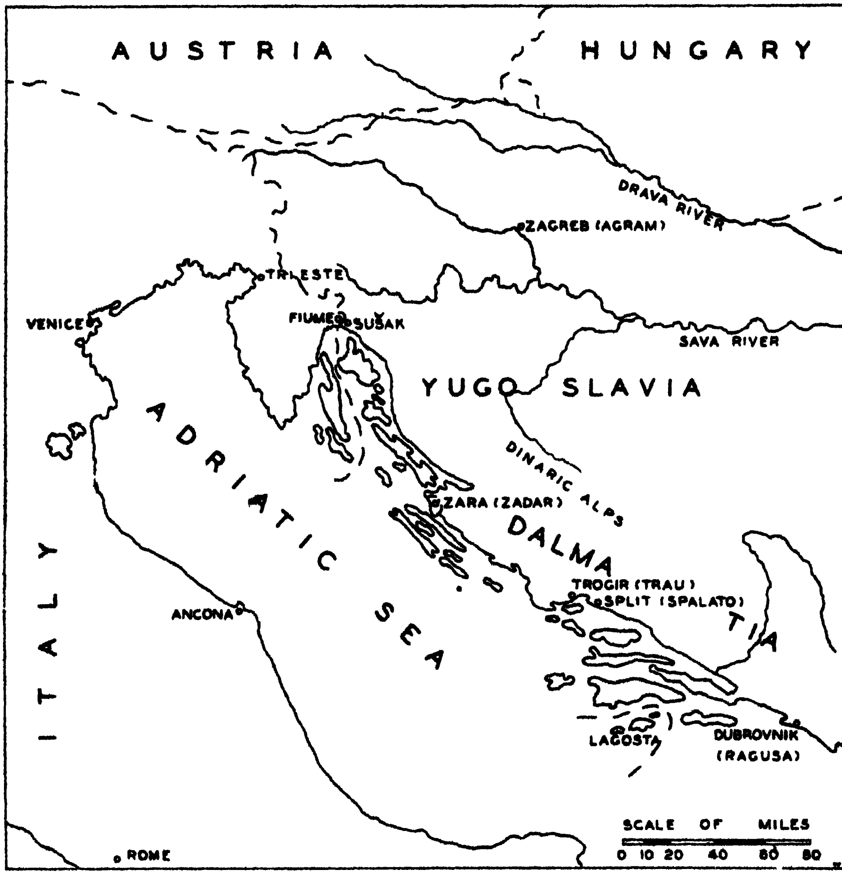


FIG. 47.—Map of the Dalmatian coast

formerly used when the country was a part of the Austria-Hungarian empire appear in parentheses.

On arrival at Split we were met at the landing by Mr. Stanko Gučič and Mr. Alfred Fey, representative of the W. T. Rawleigh Company, exporters of pyrethrum. Split, formerly called Spalato, is a city of nearly 50,000 inhabitants and is the main seaport of Yugoslavia. Accompanied by Mr. Čečuk and Mr. Fey we visited the Agricultural

A Pyrethrum field near Trogir photographed in August The plants will flower the succeeding May and June B Field of pyrethrum in bloom Photographed by S Čečuk C Pyrethrum flowers Photographed by S Čečuk

A. View of Trogir, a Dalmatian pyrethrum center. B. Left to right, Mr. Stephen Čečuk, government agent in charge of pyrethrum production and exportation control; Mr. Peter Novak, station entomologist; and Mr. Alfred Fey, representative of the W. T. Rawleigh Company, exporters of pyrethrum. C. Mr. Čečuk and Mr. Halbärth with the latter's pyrethrum mill in the background.

Institute and Experiment Station. The departments include Chemistry, Plant Pathology, Soils, and Entomology. The chemical work is mainly centered on analyses of wine and olive oil. A new laboratory for pyrethrum analyses is contemplated for Mr. Čečuk. We examined the experimental plots where selection tests are under way to improve the quality of pyrethrum. Mr. Peter Novak, the station entomologist, showed us the insect collection including a fine series of cave *Coleoptera*. Nor did we fail to visit the famed ruins of the Palace of Diocletian, dating from the third and fourth centuries A.D., the walls of which enclose an area of nearly ten acres in the center of the city, now occupied largely by dwellings housing 3,000 people. Diocletian will be remembered as the Roman emperor who voluntarily abdicated the throne and is said to have written his colleague that he preferred growing cabbages in his native Dalmatia to being emperor at Rome!

The agricultural assets of this country are not at first apparent as from the sea Dalmatia appears to be a barren waste. Inland, however, we find fertile soil but the distribution is very irregular, no large contiguous areas being under cultivation. This hidden nature of the country was very forcibly brought to our attention by an auto trip to Trogir, a pyrethrum center about 25 km. from Split. The country is of limestone formation. The agriculture is primitive with scattered plantings and the surface so irregular as to be unsuitable for the employment of machinery. Oxen and donkeys are the common beasts of burden. The dominant tree is the rock pine (*Pinus maritima*) but the forested area of Yogoslavia lies farther inland. One sees grapes and olives in abundance. Figs, almonds, peaches, vegetables of all kinds, lavender, and various medicinal plants are grown. The famous maraschino cordial is made from cherries native to this country. Casava grows wild. Everywhere one sees sheep and cattle.

At Trogir we met several of the growers and visited the pyrethrum fields. The best pyrethrum is grown at an elevation of about 300 feet above sea level on limestone soil. Pyrethrum (*Chrysanthemum cinerariaefolium*) is a biennial and blooms in May and June (Pl. 25, B and C) so that the fields visited will not bear until next year (Pl. 25, A). At that time the plants were six inches in height, while the mature plant attains a height of about two feet. The pyrethrum rotation commonly practiced by the growers is as follows: pyrethrum, two years; maize, one year; wheat, one year; beans, one year. The growers received about ten dinars per kilo for last year's crop or about ten cents per pound. We visited a pyrethrum warehouse and a mill where the pyrethrum flowers were ground by two large millstones rotating in a hopper, the power being furnished by a

gasoline motor. The product of this mill was packed for the retail trade (Pl. 26, A and C).

Dalmatia produces approximately one-tenth of the world's supply of pyrethrum. Split exports about 700 tons per year which constitutes the major part of the foreign shipment.

The Yogoslav Government is making an effort to improve the quality of the pyrethrum exported,[1] by developing better technique in drying, storing, and baling. Ultimately it is planned that all Dalmatian pyrethrum offered for export will bear a government certificate of inspection based on pyrethrin content and biological analysis. Extension work is being undertaken among the growers to demonstrate the proper method of curing and handling. The method as practiced by the more progressive growers consists in picking the flowers by hand when fully opened. They are dried for not more than a day in direct sunlight after which they are dried in the shade. The flowers are baled so that parts of the inflorescence do not sift out and the bales are covered with burlap. It is necessary to overcome a tendency on the part of some growers to over-dry the flowers, as long exposure to ultra-violet light destroys the pyrethrin content.

As we left Split by rail enroute to Prague, via Zagreb, modern except for its colorful peasant costumes, we could not help but feel very grateful to our host, Mr. Čečuk (Pl. 26, B), for the courtesies extended to us while in Dalmatia and also to Captain C. Yoximovic of the Yugoslav Trade and Tourist Information Office for his letter of introduction. The policy of the Yugoslav Government in still further improving the quality of pyrethrum certainly deserves the encouragement of every one interested in insecticides.

[1]Office for Foreign Trade, Ministry of Commerce and Industry of the Kingdom of Yugoslavia, letter of October 17, 1932.

THE CHEMICAL RELATIONSHIP BETWEEN CERTAIN INSECTICIDAL SPECIES OF FABACEOUS PLANTS

By R. C. ROARK, *Insecticide Division, Bureau of Chemistry and Soils, U. S. Department of Agriculture, Washington, D. C.*

ABSTRACT

Certain insecticidal species of plants representing six genera of the family Fabaceae contain constituents that are closely related chemically. Rotenone is found in *Cracca*, *Derris*, *Lonchocarpus*, *Millettia*, *Mundulea* and *Ormocarpum*. Deguelin, an isomer of rotenone, and tephrosin, a hydroxydeguelin, are found in *Cracca*, *Derris*, and *Lonchocarpus*. Toxicarol is found in *Cracca* and *Derris*. Other constituents of minor insecticidal value are also found in these plants.

The family Fabaceae (also called Leguminosae or Papilionaceae) contains three genera, many species of which have been found to possess remarkable insecticidal properties. These are *Derris* Lour. (more properly termed *Deguelia* Aubl.), *Lonchocarpus* and *Cracca* (= *Tephrosia*). Three other genera of this family, namely *Millettia*, *Mundulea* and *Ormocarpum* are reported to contain rotenone, the most potent insecticidal constituent of *Derris* and *Lonchocarpus*.

The following table lists those species of these six genera that have been found to have insecticidal action.

DISTRIBUTION OF THESE PLANTS.- The genus *Cracca* (*Tephrosia*) includes more than 200 species growing in Africa, Australia, North and South America. Many of these are used as fish poisons. *C. virginiana*, the only species in the table growing in North America, occurs from southern New Hampshire to Florida and west to Minnesota and eastern Texas. This is a perennial herb, 10 to 12 inches high, characterized by an extensive and tough root system.

Members of the genus *Deguelia* (*Derris*) are mostly vines that climb over adjacent trees. The species listed all grow in eastern Asia and are strictly tropical. Species of *Lonchocarpus* are shrubs or trees. Cube root (*L. nicou*) is obtained from a small tree about 8 to 10 feet high. This genus is represented by African and Australian species but is especially abundant in South and Central America.

Millettia, *Mundulea* and *Ormocarpum* are tropical trees growing in Asia. Of the species listed in Table 1 those of *Cracca* seem best adapted for cultivation in the continental United States.

The content of active principles in these plants ranges on the basis of air-dry plant material from a few tenths of 1 per cent in the leaves of *C. vogelii* to more than 10 per cent in the roots of *Derris* and *Lonchocarpus*. Samples of cube root examined in the Insecticide Division of the Bureau of Chemistry and Soils have contained as high as 11 per cent rotenone.

TABLE 1. CONSTITUENTS OF CERTAIN INSECTICIDAL FABACEOUS PLANTS CLASSIFIED BOTANICALLY

Species and insecticidal part of plant	Constituents	First isolated in pure form from this species by	Insecticidal action of the plant first recorded by
Tephrosia hookeriana Wight and Arn. seeds	Unknown	——	Tattersfield and Gimingham (36) in 1932
Cracca macropoda (Harv.) Kuntze roots	Unknown	——	Tattersfield and Gimingham (35, 36) in 1927 and 1932
Cracca toxicaria (Sw.) Kuntze roots	Toxicarol	Clark (5, 8) in 1930	Tattersfield and Gimingham (35) in 1927
	Deguelin	Clark (5, 6) in 1930	
Cracca virginiana L. roots	Rotenone	Clark (9) in 1932	Little (23) in 1931
	Tephrosin	Clark (9) in 1932	
	Dehydrorotenone	Clark (9) in 1932	
Cracca vogelii (Hook.) Kuntze leaves	Tephrosin	Hanriot* (19) in 1907	Tattersfield, Gimingham and Morris (37) in 1925
	Deguelin	Clark (5, 6) in 1930	
Cracca vogelii (Hook.) Kuntze seeds	Tephrosin	Merz (26) in 1932	Tattersfield, Gimingham and Morris (37) in 1925
	Deguelin (?)	Merz (26) in 1932	
	Dehydrodeguelin	Merz (26) in 1932	
Derris chinensis Benth. roots	Rotenone	Nagai (27) in 1902	——
Derris elliptica (Wall.) Benth. roots	Rotenone	Lenz (22) in 1911	Oxley (28) in 1848; McIndoo, Sievers and Abbott (24) in 1919
	Deguelin	Clark (5, 6) in 1930	
	Tephrosin	Clark (5, 7) in 1930	
	Toxicarol	Clark (5, 8) in 1930	
	Dehydrodeguelin	Clark and Keenan (11) in 1932	
	Dehydrotoxicarol	Clark and Keenan (11) in 1932	
Derris heptaphylla (L) Merr. roots	Unknown	——	Merrill (25) in 1926
Derris malaccensis Prain roots	Rotenone	Spoon (31) in 1931	Gater (14) in 1925
	Tephrosin	Spoon (33) in 1932	
	Toxicarol	Spoon (33) in 1932	

Derris philippinensis Merr. roots	Unknown	———	Castillo (4) in 1926
Derris polyantha Perkins roots	Rotenone	Georgi and Teik (16) in 1932	Castillo (4) in 1926, and Merrill (25) in 1926
Derris thyrsiflora Benth. roots	Unknown	———	Gater (14) in 1925
Derris uliginosa (Roxb.) Benth. (= *D. trifoliata* Lour.) roots	Anhydroderrid†	Power (29) in 1902	McIndoo, Sievers and Abbott (24) in 1919
	Rotenone	Blackie (1) in 1932	
Lonchocarpus latifolius H. B. K. seeds and pods	Unknown	———	Tattersfield and Gimingham (36) in 1932
Lonchocarpus nicou (Aubl.) DC. (cube root)	Rotenone	Geoffroy (15) in 1895	Geoffroy (15) in 1895
	Deguelin	Clark (5, 6) in 1930	
	Tephrosin	Clark (5, 7) in 1930	
	Isotephrosin	Clark and Claborn (10) in 1932	
Lonchocarpus sp. (nekoe roots)	Rotenone	Spoon (32) in 1931	———
	Deguelin	Spoon (32) in 1931	
	Tephrosin	Spoon (32) in 1931	
Lonchocarpus sp. (roots and stems of white haiari)	Rotenone	Tattersfield, Gimingham and Morris (38) in 1926	Tattersfield, Gimingham and Morris (38) in 1926
Lonchocarpus sp. stems of black haiari	Rotenone	Tattersfield, Gimingham and Morris (38) in 1926	Tattersfield, Gimingham and Morris (38) in 1926
Millettia taiwaniana Hayata roots	Rotenone	Kariyone, Atsumi and Shimada (20) in 1923	———
Mundulea suberosa Benth. stems, seeds and pods	Rotenone	Greshoff (18) in 1899	Tattersfield and Gimingham (36) in 1932
Ormocarpum sp.	Rotenone	Greshoff (18) in 1899	———

*Hanriot's "tephrosine" was impure (m.p. 187° instead of 198°) and probably was mixed with deguelin.
†Anhydroderrid (m.p. 212–213°) was probably a dehydro derivative.

TABLE 2. CONSTITUENTS OF CERTAIN INSECTICIDAL FABACEOUS PLANTS CLASSIFIED CHEMICALLY

Constituent	Found in	First isolated by	Insecticidal properties of the pure compound first reported by
Rotenone, $C_{23}H_{22}O_6$, colorless crystals, melting at 163°C.	*Cracca virginiana*	Clark (9) in 1932	———
	Derris chinensis	Nagai (27) in 1902	———
	Derris elliptica	Lenz (22) in 1911	Davidson (12) in 1930 and Shepard and Campbell (30) in 1932
	Derris malaccensis	Spoon (31) in 1931	———
	Derris polyantha	Georgi and Teik (16) in 1932	———
	Derris uliginosa	Blackie (1) in 1932	———
	Lonchocarpus nicou	Geoffroy (15) in 1895	Geoffroy (15) in 1895
	Lonchocarpus sp. (Haiari)	Tattersfield, Gimingham and Morris (38) in 1926	Tattersfield, Gimingham and Morris (38) in 1926
	Lonchocarpus sp. (Nekoe)	Spoon (32) in 1931	———
	Milletia	Greshoff (18) in 1899	———
	Mundulea suberosa	Greshoff (18) in 1899	———
	Ormocarpum	Greshoff (18) in 1899	———
Deguelin, $C_{23}H_{22}O_6$, pale green crystals, melting at 171°C.	*Cracca toxicaria*	Clark (5, 6) in 1930	———
	Cracca vogelii	Clark (5, 6) in 1930	———
	Derris elliptica	Clark (5, 6) in 1930	Davidson (12) in 1930 and Shepard and Campbell (30) in 1932

Tephrosin, $C_{23}H_{22}O_7$, colorless crystals, melting at 198°C.	*Lonchocarpus nicou*	Clark (5, 6) in 1930	———
	Lonchocarpus sp. (Nekoe)	Spoon (32) in 1931	———
	Cracca virginiana	Clark (9) in 1932	———
	Cracca vogelii	Hanriot (19) in 1907	———
	Derris elliptica	Clark (5 7) in 1930	Davidson (12) in 1930 and Shepard and Campbell (30) in 1932
	Derris malaccensis	Spoon (33) in 1932	———
Toxicarol, $C_{23}H_{22}O_7$, greenish-yellow crystals, melting at 219°C	*Lonchocarpus nicou*	Clark (5, 7) in 1930	———
	Lonchocarpus sp. (Nekoe)	Spoon (32) in 1931	———
	Cracca toxicaria	Clark (5, 8) in 1930	———
	Derris elliptica	Clark (5. 8) in 1930	Davidson (12) in 1930 and Shepard and Campbell (30) in 1932
	Derris malaccensis	Spoon (33) in 1932	———
Dehydrodeguelin, $C_{23}H_{20}O_6$, melting at 233°C.	*Cracca vogelii*	Merz (26) in 1932	Not tested
	Derris elliptica	Clark and Keenan (11) in 1932	
Dehydrotoxicarol, $C_{23}H_{20}O_7$, melting at 235–236°C.	*Derris elliptica*	Clark and Keenan (11) in 1932	Not tested
Isotephrosin, $C_{23}H_{22}O_7$, melting at 252°C.	*Lonchocarpus nicou*	Clark and Claborn (10) in 1932	Not tested
Dehydrorotenone, $C_{23}H_{20}O_6$, melting at 224°C.	*Cracca virginiana*	Clark (9) in 1932	Shepard and Campbell (30) in 1932

The amount of rotenone and other insecticidal constituents in these plants varies greatly according to the species and maturity of the plant, the nature of the soil in which grown and other factors.

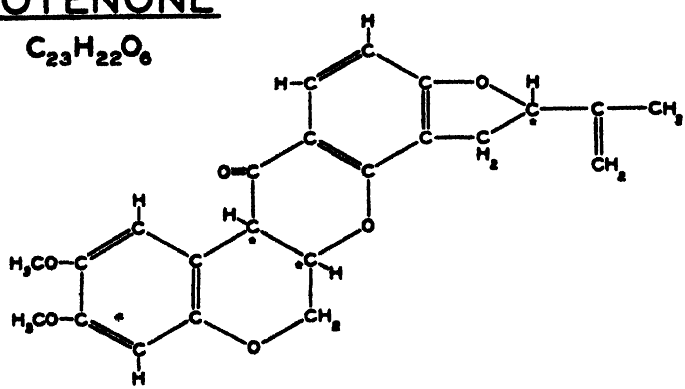
A chemical classification of the constituents of these plants is shown in Table 2.

The complete structural formulae of rotenone, deguelin and tephrosin are now known as the result of investigations by LaForge, Haller and Smith (21), and by Clark (5–10).

Rotenone is represented by the following formula:

ROTENONE

$C_{23}H_{22}O_6$



The relative toxicity to goldfish of these compounds has been determined by Gersdorff (17) to be:

Rotenone	toxicarol	deguelin	tephrosin
1	0.65	0.56	0.23

A concentration of 0.075 mg. rotenone per liter (1 part in about 13,000,000) at 27° C. kills goldfish in two hours.

When sprayed upon the bean aphid (*Aphis rumicis*) as an aqueous suspension without soap or other wetter or spreader, Davidson (13) found the order of toxicity to be, roughly:

Rotenone	deguelin	tephrosin	toxicarol
400	40	10	1

Shepard and Campbell (30) tested these compounds by the leaf-sandwich method of Campbell and Filmer (3) as modified by Campbell (2) on fourth instar silkworms and found the following order of toxicity:

Rotenone	deguelin	tephrosin	toxicarol

The median lethal dose of rotenone in these tests was approximately .003 mg. per gram of bodyweight or 1/30 that of acid lead arsenate.

Both Davidson and Shepard found rotenone more toxic than nicotine to *Aphis rumicis*. The toxicity of deguelin and nicotine has not been directly compared but judging by the concentrations at which deguelin is effective, it is almost certainly more toxic than nicotine.

Dehydrodeguelin, dehydrotoxicarol and isotephrosin have not been tested for their insecticidal action. Dehydrorotenone was found by Shepard and Campbell (27) to be less than 1/100 as toxic as rotenone as a stomach poison to silkworms.

The genera in which rotenone and related compounds occur comprise several hundred species. It is believed that experimenters testing these species will be well rewarded by the discovery of insecticidal constituents [1]

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[1]Since this manuscript was prepared (August, 1932), rotenone or related compounds have been found in the following additional plants by members of the Insecticide Division: *Derris grandiflora*, *Lonchocarpus guatemalensis*, *L. velutinus*, *Polygonum* (?) *sp.*, *Spatholobus roxburghii* (Jones, Jour. Amer. Chem. Soc. 55. 1737–1738, 1933), *Tephrosia candida*, *T. cinerea* and the following as yet unidentified plants: Cipo, berberra seeds, bejuco de gusano (possibly *Lonchocarpus hondurensis*), barbasco root, sopilote wood and la meh seeds.

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Section of Plant Quarantine and Inspection

Wednesday Morning Session, December 28, 1932

The meeting of the Section of Plant Quarantine and Inspection of the American Association of Economic Entomologists convened at 10:20 a. m., in the Viking room of the Chalfonte Hotel, Atlantic City. Mr. W. A. Price, Chairman of the Section, presided.

The Chairman appointed the following committees:

Resolutions: A. F. Burgess, Chairman, E. L. Chambers and C. H. Hadley.

Nominations: G. M. Bentley, Chairman, and W. E. Britton.

ADDRESS OF THE CHAIRMAN

By W. A. Price, *Lexington, Ky.*

It gives me great pleasure to appear before this group and it is with the profoundest recognition of the importance of the plant quarantine work that I address you. I need not call to your attention the fact that we are just now passing through a crisis such as we have not experienced in the history of our work. Fortunate it is for us that our predecessors have laid the foundations of quarantine control well and the accumulated momentum of their efforts, so to speak, will assist in carrying us far, we hope, through this present crisis. However, we dare not rely on this good fortune, but we must be vigilant and untiring in directing our energy into those channels where the most good will be accomplished.

As your chairman I wish to make a plea to you for close and keen discrimation as to the relative merits of the different phases of our work. Important as all phases of quarantine control are, the present situation forces us to be selective. Many of you, in fact most of you, have suffered a reduction in budgets in the past months. Reduced budgets mean reduced service. Let us be wise, let us see big issues, in order that our work may suffer as little as possible.

Cramped as we are for funds locally, we have had added burdens placed upon us. Reduction in government appropriations for regulatory work has forced the lifting of some federal quarantines entirely and has greatly reduced the extent and activity of others. No one will question the fact that a quarantine placed and operated by the Federal Government is much more satisfactory than any maintained by one of several states. Reduced revenue however, forced the Quarantine Bureau at Washington to consider where they could most wisely spend the funds available. The lifting of quarantines in certain areas has placed the

burden on the states of those areas. Each state must act as a unit in attempting to check the spread of insect pests and plant diseases. In the early history of regulatory work it was essential that there be the closest harmony between the various agencies of the Federal government and the states. The smoothness with which the system has worked has almost caused us to forget that that cooperation had to be established in the beginning. Unless there is such close cooperation between the agencies and between the states many hardships will result to dealers, shippers and growers.

With the lifting of Federal quarantines many states will resort to the placement of embargoes as this seems to be the simplest, cheapest and most effective means of preventing diseases and insects from entering restricted areas. The mere announcement of such embargoes makes the shipment of host plants from an infested area into a restricted one a violation of the law. Certificates are neither issued nor recognized The burden is placed entirely upon the people in the embargoed states It is not necessary to say that promiscuous use of embargoes placed upon the necessities of life is not only impracticable but almost impossible When we restrict the shipment of commodities we at once enter the field of economics. Prices are affected because of limited markets. Before any embargo is placed upon any commodity careful and thoughtful consideration should be given to the matter. The idea is to keep out the harmful disease or insect rather than the commodity.

Frequent and careful inspection of regularly established nurseries and nursery stock must be continued. Able inspectors trained in entomology and plant pathology must be retained in the service. Every state must do this not only to protect its own citizens and its own nurserymen but to protect neighboring states and to insure the recognition of its own certificates.

No doubt, in many states with reduced budgets the question of how a high standard of inspection may be maintained, has arisen. It is my belief that an inspection fee system is very satisfactory. Firstly, it furnishes needed revenue at a nominal cost to the nurseryman. Secondly, it has an excellent psychological effect. Each nurseryman under such a system feels he is a shareholder in the business. A service has been rendered to him for which he has paid and he holds his credentials. He has an interest in promoting the business and in demanding that it render him a high type of service. He is zealous in his demands that all other nurserymen or vendors of nursery stock be held to the same standards which he maintains. When the service is apparently free to him this wholesome feeling is often entirely lacking. Practically all

good nurserymen have come to realize that the system of inspection was established for them and that a rigid enforcement has been to their best interest and to that of their customers. The amount of revenue to be derived under the fee system depends upon the size of the fee charged and upon the number of nurserymen in any state. It is probably advisable in most states to have a moderate fee supplemented by state appropriation

Sullivan in his address before you a year ago spoke at some length about the problems that have grown with the development of improved highways and the trucking business. He stated that it is not at all uncommon for truck-loads of plants and plant parts to be transported halfway across the continent. One phase of this problem is giving us more anonyance in Kentucky at the present time than any other relating to inspection work. The great number of estates of very wealthy persons in the Blue Grass area creates a demand for expensive ornamental planting on a large scale. One of the most popular shrubs about these estates is the old-fashioned boxwood We all know that boxwood is extremely slow of growth and therefore if purchased from a nursery is usually relatively small. Now it seems that boxwoods of very large size and beautiful proportions can be obtained in some of our neighboring and nearby states, at a much lower price than that at which nurserymen can furnish them Independent truckmen knowing of this supply and demand have engaged in a business both simple and lucrative. Often a single plant will sell for three or four hundred dollars The boxwoods and some other stock which is gathered up promiscuously are transported by truck over improved highways. These shrubs do not come from nurseries and are not sold by nurserymen. They are therefore uninspected and capable of disseminating injurious insect pests and plant diseases

I have reason to believe that there are states, other than Kentucky, to which such shrubs are being transported and I have no doubt many of you are facing the same problem. It is not at all uncommon to meet groups of several trucks, bearing foreign license plates and loaded with these large shrubs, traveling over our highways. Whither they are going we know not. What is the solution? Will it mean inspection at point of entry for every state? With these itinerant truckmen peddling stock from door to door it is difficult for any agent to render an inspection. Such peddlers have no terminal point. They have no place of business. It is, no doubt, fortunate that our regularly licensed nurserymen are interested and have informed us frequently of the presence of these vendors. I need not say to you that the enforcement of the nursery

inspection law under these conditions is most irregular and unsatisfactory. Undoubtedly the complications arising from the transportation of plants over improved highways will constitute one of our biggest problems in the future.

THE PRESENT STATUS OF THE GIPSY MOTH

By A. F. Burgess, *Greenfield, Mass.*

The gipsy moth program as it has been dealt with for the last 25 years has had for its purpose the prevention of the spread of this insect throughout the United States. An examination of the literature and the reports that have been received from many foreign entomologists, as well as specialists sent to foreign countries to study this insect, indicate that it has a wide range of distribution and there seems to be no doubt that it could survive and become a destructive pest in nearly all sections of the United States

The work that has been carried on by the United States Department of Agriculture has been in close cooperation with the infested States and is based upon the premise that in case of an introduced insect which occupies only a small area and is likely to cause tremendous damage, the expenditures for control and prevention of spread should be shared by the States and the Federal Government

For the first few years during which there was Federal participation in this work, the utmost efforts were expended by the Government and the infested States to reduce the tremendous infestation that had built up in the residential sections of the infested area and in woodland areas adjacent to travelled roads, in order to prevent the spread to uninfested territory.

In 1913, after the plant quarantine act was passed, a system of inspection and certification of products and materials likely to carry infestation was developed and has been in effective operation since that time In fact very few cases have been found during the last 20 years where new infestations in outside territory could be directly traced to material that had been moved from the territory under quarantine. This in itself is an unusual showing and should be conclusive evidence of the value of this feature of the work.

About the time the Federal quarantine became effective a rearrangement was made of the field work on this insect and the plan adopted has been followed with some modifications since that time. It was arranged that the Federal field work would be confined to the outside

border of the infested area for the purpose of determining the extent of infestation and where the pest was spreading, and to clean up the infested areas that were discovered. The efforts of the States would be confined to the territory within this outer border and would be administered for the purpose of reducing the infestation for the protection of their own citizens and to assist in preventing further spread. This made it possible to determine from year to year the area that should be placed under quarantine and to improve the conditions of infestation in the territory that had been longest infested so as to minimize the danger of transmission of the insect on products that might be shipped therefrom

For a number of years the infestation was so severe and the infested territory extended so rapidly that it was impossible to secure effective control with the funds that were available. After it was demonstrated that one of the principal means of spread was due to newly hatched caterpillars being carried by the wind, it became evident that another important feature had to be considered in planning the work to prevent spread.

In 1920, a heavy infestation was found near Somerville, New Jersey, and as this was an isolated colony cooperative effort was begun by the Federal Government and the State to effect its extermination. This developed into one of the largest projects of its kind that has ever been attempted and owing to the effective cooperation, ample financial backing and the united effort of a trained personnel, extermination is believed to have been accomplished An area of over 400 square miles which was found to be infested has been cleaned up and this together with the territory surrounding it made necessary the examination of over 2300 square miles before the result was accomplished.

In 1922, several colonies of the gipsy moth were found in New York State directly west of the Massachusetts line. This was the result of rather constant spread from year to year which was impossible to prevent with the funds available to examine and treat an ever increasing border. A conference was held in Albany in November of that year which was attended by representatives from all of the infested States and those adjoining, officials from the Department of Agriculture at Washington and the Entomological Branch of Canada, and as a result of a thorough discussion of the subject a plan was evolved for establishing a barrier zone about 30 miles wide extending from the Canadian border to Long Island Sound bounded on the west by the Hudson River, for the purpose of cleaning up infestations in this area and keeping it free from reinfestation in order that the westward spread of the pest

might be prevented. This zone has been operated for the past ten years and many infestations have been exterminated within its boundry. Large areas of territory have been examined at various times adjoining the zone to the west and only two or three small sporadic infestations have been found and these have been promptly exterminated.

The Entomological Branch of the Department of Agriculture of Canada have carried on scouting work at various times in the territory adjoining the International Line and a single infestation was found in 1924 in the township of Lacolle, which is directly north of Rouses Point, New York. This infestation was promptly cleaned up and no further infestations have been found on the Canadian side of the border.

Since 1927, attention has been called to the fact that gipsy moth infestation was building up gradually east of the zone and the need for some protective work in that area has been repeatedly stressed. During the last fiscal year conditions in the zone in Vermont have shown improvement but in a group of towns in southwestern Massachusetts and northwestern Connecticut the insect has continued to persist in spite of continued efforts to control it. From the location of the new colonies that have been found it is evident that there has been considerable wind spread into the zone from territory to the eastward and this condition which was predicted some years before, has made the maintenance of the zone increasingly difficult.

Field work in the zone has been carried on in New York State in the territory south of Fort Ann by the State Department of Conservation, the remaining territory in northern New York and in the adjoining New England States being done by the Bureau of Plant Quarantine. In the entire area there are approximately 3,000,000 acres of woodland. Up to the present time about 2,000,000 acres have been scouted and infestation has been found only in the southwestern Massachusetts and northwestern Connecticut areas and in several locations directly west of it in New York State. There remains about 1,000,000 acres which should be scouted in order that this project may proceed with reasonable assurance of success.

Owing to the drastic reduction in funds for the present fiscal year all scouting of woodland areas in the barrier zone have been abandoned and in July, when a new infestation was discovered near Pittston, Pennsylvania, it was necessary to divert a large proportion of the funds from the barrier zone project in order to start work in that region. It will be impossible to do the work that is urgently needed in the worst sections of the barrier zone during the present year and the danger of increase and spread of the insect is imminent.

During the past 10 years several small infestations have been found on Long Island. Most of the control work there has been done by the State of New York but at various times scouting has been carried on by the Federal force when New York funds were not available for that purpose. In the Fall of 1929, a serious colony was found near North Roslyn, Long Island. Scouting and clean up work was carried on temporarily by the Federal forces and later, after State funds were available this work was taken over by the State Conservation Department. Progress is being made in cleaning up this infestation although some additional work remains to be done. Material likely to carry infestation is being inspected and certified by Federal inspectors before it moves from the area.

The gipsy moth problem in Pennsylvania centers around the city of Pittston in the Wyoming Valley. Work has been taken up cooperatively with the State Department of Agriculture and the Department of Forests and Waters. $70,000 was diverted from the barrier zone work in New England for use in this area and the State furnished headquarters and storage facilities and paid some minor expenses until such time as legislative action can be secured. In September a force of 50 trained and experienced men were detailed to carry on scouting work to determine the extent of the infestation and by early November it was found that an area surrounding Pittston, embracing about 15 square miles was heavily infested. Scattered infestations were located in a territory surrounding this area of about 95 square miles. As infestations were found in some parts of the territory as far as the scouting work was carried on, it will be necessary to examine the roadways, trees on private property and along the edges of woodland, and in some sections the woodland itself, in an additional area of about 150 square miles.

The area adjoining the Susquehanna River including sections that are flooded at high water has been examined from Nanticoke to beyond the Ransom township line, and the Lackawanna River as far north as the city of Scranton. A few infestations were found on the Susquehanna River but more were discovered on or near the Lackawanna River, and in all probability further infestation will be found when work is taken up in Scranton and the territory immediately surrounding it.

It is very necessary that all infestations that can be found should be thoroughly treated before the eggs hatch in the Spring.

No quarantine has been placed on the area known to be infested but shippers of trees and plants have been notified that this material must not be moved until it has been inspected and certified. Means have been taken to check up on the movement of material from badly infested localities and action is being considered concerning the placing of a

quarantine that will safeguard the products moved and protect purchaser and the shipper.

The results that have been secured from the work attempted in the Wyoming Valley in Pennsylvania, indicate that the extermination of the gipsy moth in that region is the most practical way of handling the problem. The task is difficult on account of the general favorability of the food plants and the rugged wooded country flanking the valley. It is the most feasible way of meeting the situation and protecting the enormous forest areas of Pennsylvania and the surrounding States.

The tremendous value to the country at large that has resulted from the enforcement of the gipsy moth quarantine is not fully realized. The quarantined area in New England is the source of many kinds of plant products that are moved to all parts of the United States. It is difficult to determine the value of the products whose movement is safeguarded as a result of the inspection system that is being maintained and which for nearly twenty years has efficiently performed its function with a minimum of inconvenience to the shipper and a maximum of security for the purchasers. It is believed that several million dollars represents a very conservative value for the material that is shipped annually from the quarantined area. In planning the work for the present year very slight change was made in the amount of funds to be expended for quarantine enforcement, as this is considered to be the only means of preventing long distance country wide spread.

Under present conditions the question naturally arises what should be done to meet the situation. One of three courses could be adopted.

FIRST: To exterminate the Pennsylvania infestation in cooperation with that State, abandon the barrier zone, and divide the small amount of money that would be available between carrying on promiscuous scouting work (which in our experience is rather ineffective) in territory located somewhere west of the present barrier zone in New York, and quarantine enforcement in the abandoned area. Under this plan the present quarantine should be extended by placing the area from the east zone line to the territory where promiscuous scouting will be done, under quarantine regulations so as to protect it from shipments from the present badly or generally infested area and to protect other sections of the United States from possible infestation from shipments that come from the abandoned territory.

SECOND: To carry through the extermination project in cooperation with the State of Pennsylvania, to maintain the barrier zone in cooperation with the State of New York, and continue the plan that has been effective for the past ten years in preventing the westward spread

of the pest. This plan would mean an increase in expenditures for the emergency work in Pennsylvania and an increase over present available funds to continue the plan in the zone.

THIRD: To follow through plan two and supplement it by the establishment of a protective area between the zone and the Connecticut River extending about as far north as Rutland, Vermont, in order to prevent reinfestation of the zone from the east. This plan would call for additional funds. It would also give additional protection. It is believed that if this plan for future work is adopted and necessary funds made available, sufficient work can be done so that some towns in the western border of the zone may be released from time to time and more work done in towns directly east of the zone line in the section north of Rutland. Throughout a great portion of that territory millions of trees are cut every year and sold for Christmas decorations. This means considerable expense for inspection as most of them are shipped outside the quarantined area and many of them to far distant points in the United States. By adopting this plan, as territory is released on the western side of the zone a gradual reduction of the area under quarantine could be made. This plan affords ample protection to the forest and shade tree interests of the uninfested States. It will be more expensive for a time but will result in a gradual reduction in local expenditures in the western part of the zone as territory is released.

Past experience indicates that this plan is feasible and based on the value of the interests involved is a sensible as well as economical method of protection and of preventing this perpetual drain on the natural resources of the entire United States.

Larval Parasites of the Codling Moth in the Santa Clara Valley, California. — During the past three years while conducting experimental work in codling moth control in Santa Clara County, California, several thousand mature codling moth larvae were collected from beneath bands and reared out in order to obtain eggs and young larvae for laboratory experiments. Two species of larval parasites have been reared from these several thousand larvae. The first of these is the codling moth tachinid, *Lixophaga variabilis* (Coq.) (Hypostena). This parasite has previously been reared from the same locality by J. F. Lamiman. (Unpublished thesis, University of California, 1924.) In these investigations natural parasitism by this insect was found to run as high as five per cent in some collections of larvae. The second parasite reared was hymenopteron of the family Braconidae, *Ascogaster carpocapsae* (Viereck). The percentage of parasitism by this species is very low as but a few specimens have been obtained. So far as it has been possible to determine, this is the first record of this species from the above mentioned locality.

GEORGE S. HENSILL, *Division of Entomology and Parasitology, University of California, Berkeley*

EXPERIENCE IN ENFORCING COMPULSORY CLEAN-UP REGULATIONS ON ACCOUNT OF THE EUROPEAN CORN BORER

By W. E. Britton, *State Entomologist, New Haven, Conn.*

Abstract

Brief summary of three seasons' experience in enforcement of a compulsory clean-up law in Connecticut for the control of the two-generation European corn borer, *Pyrausta nubilalis* Hubn. Methods of procedure, difficulties and results are described.

The Connecticut General Assembly of 1929, as an aid in the control of the two-generation European corn borer, enacted a law requiring growers to dispose of all cornstalks, and weeds subject to infestation, before April 10 of each year, provided the Director of the Connecticut Agricultural Experiment Station issues an order to that effect. Such order is applicable only to territory under state quarantine The States of Massachusetts and Rhode Island had enacted similar measures prior to the passage of the Connecticut law.

This measure was first enforced in 1930, when the southeastern portion and slightly less than half of the area of the state was under quarantine. Considerable newspaper publicity was given the matter explaining the law, the Director's order, and the damage caused by the borer. Four days after the time limit set, seven inspectors were sent through the area, each inspector being furnished with an automobile, and instructed to cover nine or ten towns. When any cornstalks or stubble were observed the inspector interviewed the owner or manager and filled out an order on a blank card prepared for the purpose. This card was in the form of a return postcard. The owner was asked to sign the order promising to comply on or before a certain date specified. Usually several days were allowed for the necessary clean-up. The signed card was returned to the office by the inspector and the other left with the owner to be signed and mailed as soon as the work was completed. The seven inspectors were engaged in this work for about two weeks while they covered 72 towns and issued 749 cards. Of this number 685 cards or 91.4 per cent, were returned to the office stating that the work had been completed. As this was the first attempt at enforcement no real effort was put forth to follow up the others. In some cases the writing was illegible, and education was the chief object sought. The inspectors were all Federal employees and only their expenses were borne by the state. The cost to the state was just under $400.

Federal scouts in 1930 found that many additional towns were infested so that in the spring of 1931 more than three-fourths of the state was quarantined. Notices were issued through the newspapers and 16 inspectors were sent into the field and worked about a month. The same card system was used except that the cards were numbered serially and the same number stamped on each section of the double card to facilitate identification These inspectors visited 137 towns and issued 1,562 notices, and 1,377, or 88.8 per cent were returned stating that the clean-up work had been completed Some of these cards were not received at the proper time and letters were sent to the growers who had failed to respond. Some 28 of these letters were returned undelivered, due perhaps to the inability of the office force to decipher the names, many of which were foreign No other follow-up measures were practiced. The cost of this work in 1931, exclusive of supervision, was about $1,178.83.

In 1932 the insect had spread to such an extent that the Federal and state quarantines were placed over the entire state Wide publicity was given the clean-up order Consequently, 23 inspectors, in charge of M. P. Zappe and J P Johnson, were employed for about six weeks to cover the 169 towns in the state, and a re-check was made during a second visit. They used the same card system and issued about 3,750 cards, of which 3,604, or 96.1 per cent, were completed and reports returned There were 146 that failed to report. These were nearly all again seen by the inspectors or supervisors. A large proportion had cleaned up but had lost or mislaid their cards, and claimed that they didn't know whom to address. Some others had taken no action but promised to do so at once and our men saw that the work was completed. Altogether, seven refused or neglected to take action and were reported to the prosecuting attorney or to a grand juror of the town and the men were brought into court. All were made to clean up and their action checked by the state police. Two were given small fines, and six were assessed costs. The cost of gasoline, oil and other traveling expenses together with the salaries of inspectors and supervisors for enforcing the clean-up in 1932 was $4,331.17.

In this work, clean-up was enforced only in the rural districts and no attempt was made to cover back-yard gardens in villages and cities. One frequent difficulty arose in regard to rented property. The tenant perhaps planted a field of corn and in the fall moved away leaving the cornstalks standing in the field. In such cases the owner usually felt that he was not responsible and should not be obliged to dispose of them. However, it seems to be a principle of law that in the last analysis the

owner must be held responsible for any nuisance, or for compliance with any legal regulations affecting his property. Another difficulty presents itself in case of bankruptcy proceedings, as it is sometimes necessary to issue an order to the receiver. In all prosecutions the courts gave satisfactory help and cooperation.

APPLICATION OF HORSE SENSE TO PLANT QUARANTINES

By Thomas J. Headlee, Ph.D., *State Entomologist of New Jersey*

In this paper I will make no attempt to consider the regulation of insect carrying products moving across international boundary lines, not because I have information to show that such regulations are above reproach, but because I realize that my knowledge and experience are insufficient to justify me in venturing on such ground The domestic plant quarantine, both federal and state, represents the field which I desire to consider.

Source of Basic Principles.—Basic principles for plant quarantine procedure are usually sought in the biological and economic aspects of the parasite organism, against which it is desired to erect barriers. With attention centered upon the organism and the harm which it can presumably do, it is easy to overlook or underestimate the effect on organized society, which will be wrought by regulations designed to prevent the spread from infested to uninfested territory. So far as known, no one has as yet worked out the full effects of any plant quarantine. Efforts have been made in a number of instances to estimate, more or less closely economic benefit and economic damage done by certain plant quarantines. No one has been much impressed with the idea that any or all of these efforts has in any case given a complete picture of what has happened.

Every quarantine equation has in it many imponderables in the way of psychological effects, the results of which are extremely difficult, if not impossible to measure. Every material disturbance of social customs, habits, and procedure has far-reaching effects.

Evidently, then in a search for basic principles of plant quarantine procedure it is not enough to study the biologic and economic aspects of the parasite organisms but any study worthy of the name must include the social factors of human psychology and activities.

Qualification of a Situation for Quarantine.—From the standpoint of the parasite organism and human welfare, the following questions must be answered clearly in the affirmative or the situation does not qualify for quarantine regulations.

(1) Is the organism potentially capable of economic damage in uninfested territory under the topographic, climatic and biologic conditions obtaining therein?

(2) Is there any sound reason that gives fundamental support to the idea that it can be exterminated where once established or is there any reason or set of reasons to indicate definitely that the organism can be held to the area of present infestation?

(3) Will extermination more than counterbalance the cost of the operation and the losses to Industry and commerce the effort will entail?

(4) Will prevention of spread perform an economic service materially greater than the cost of the operation and the losses to industry and trade the effect will entail?

The only type of domestic plant quarantine in operation today, which fails to answer these questions in the affirmative, is the quarantine which claims merely to retard spread of the parasite organism. There are many examples of this type. For the operation of this type of quarantine the one-sided reason is given that a few more years of freedom for uninfested territory saves in the aggregate an enormous expense which otherwise would be visited upon the growers of the uninfested territory. The writer calls this a one-sided reason because it fails to subtract from this assumed benefit the losses due to interruption and disruption of the flow of normal legitimate business activities occasioned by the quarantine. Furthermore, the presumption of benefit is vitiated by the fact that it is predicated on the assumption that the parasite's activities will be the same in nature and degree in the uninfested territory as they have been found to be in the infested territory; an assumption not only not necessarily sound but surely unsound in some cases and very probably unsound in other cases.

It is easy for the law enforcement organization to yield to the public psychology of fear and place quarantines against the object of that fear. In fact, a man who refuses to cater to the fears of his people in these matters must be of an understanding mind and have his feet well planted. Indeed, he should, before the building up of fear takes place among his people, see it coming and turn their psychology away from it. It takes great foresight and real courage to do a thing of this sort.

State and Federal Domestic Quarantines.—Domestic plant quarantines may originate in states or in the Federal government. Plant quarantines originating in the state would naturally be supposed to regulate intrastate matters but as a matter of fact most of them seem to be concerned with interstate commerce in that they are designed to pre-

vent or retard entrance into the quarantining state of some plant parasite known to occur in territory outside the state. It seems perfectly clear then that most domestic quarantines originating with the states attempt in part to regulate interstate commerce, a field especially given over by the constitution to federal action. From various decisions of the Supreme Court, it seems that in the absence of federal action the state is free to put into force regulations affecting interstate commerce. It is presumed that the plant quarantines originating in the states and affecting interstate commerce have their legal justification in this point

Furthermore, it is, of course, possible for a state under intrastate quarantine to interfere with interstate commerce indirectly by preventing the state consignee of the interstate moving goods from distributing the goods within the limits of the state, but concerning legality of this procedure there might be a question raised and this question might or might not be settled to the satisfaction of state quarantine authorities Furthermore, state quarantines affecting interstate business can be avoided by the subterfuge of shipping into another state to a certain consignee and rebilling to the quarantined state

There is no doubt that such a situation as above outlined exists now with plant quarantines originating in the states independently of federal action. Such a situation is loaded with dynamite and needs only a few hotheaded quarantine officials to set it off. Such a situation is dangerous to large and important business interests, to agricultural producers, and especially to professional entomologists everywhere.

For its own good and the good of the country as a whole, no state should put on quarantines regulating interstate commerce directly or indirectly without federal action and entomologists should see to it that nothing of this sort occurs with their concurrence and support. In fact, it seems to the writer, that the responsibility for preventing such things rests upon the state entomological officers.

Regardless of the lack of wisdom in trying merely to retard the distribution of insect species, better protective results of a character usually sought by state plant quarantines can be secured through the use of the federal tag. Goods equipped with this tag should go freely in all such regions of the United States as are specified on the tag.

Demands of Horse Sense.—The general public is tired of the state and federal quarantines that move their lines back from time to time and regards such retirement as definite confession of failure. The general public believes that public funds spent in such quarantines is wasted and is not disposed much longer to support them.

Let us consider the bearing of common or horse sense on the matter of

quarantines. Insect species are being more or less rapidly distributed over the world. The United States has already received many species and is due to receive many more. Such introductions usually, but not necessarily, start at one point. Within continental United States there is constantly going on a process of country-wide distribution of species not as yet all over. Furthermore, with species already fully distributed, there is a constant movement with commerce from one part of the county to another.

In view of this situation what kind of domestic plant quarantine regulations are logical and effective? In the first place, the quarantine which accompanies *extermination* and is necessary thereto is logical and sound. In the second place, the quarantine which actually *prevents* distribution without entailing too serious readjustments of business and agriculture is worthwhile. In the third place, the use of the United States tag with its declaration of freedom from specified species and its specification of the parts of the United States into which it may be shipped is, with present psychology, an inescapable necessity if commerce between the states is not to be seriously disrupted.

This means the abrogation of some of our present federal quarantines, the elimination of the purely state quarantines which affect interstate commerce, and a close and effective cooperation between state and federal plant parasite regulatory forces in the use of the United States tag.

Fortunately, instrumentalities are at hand for bringing about these results, which are merely the plain dictates of common sense applied to our present domestic quarantine situation. The writer refers to the Plant Quarantine and Control Administration under the leadership of Mr. Lee Strong and the National Plant Board under the leadership of Professor Walter C. O'Kane.

In face of the present plant quarantine chaos, which seems from the state angle to be increasing, I repeat that these three foundational propositions represent the least that common sense treatment of the case requires. More can hardly be expected in view of present plant pest regulatory psychology and less should not be tolerated.

REPORT OF THE CENTRAL STATES PLANT BOARD

By P. T. ULMAN, *Secretary*

The eighth annual meeting of the Central States Plant Board was held on March 4 and 5, 1932 at Wooster, Ohio. Twenty-four entomologists and inspectors were in attendance representing seven of the thirteen states comprising this section of the National Plant Board. The states represented were Ohio, Wisconsin, Kansas, Indiana, Illinois, Minnesota, Missouri. In addition E. N. Cory of College Park, Maryland, Lee A. Strong, S. B. Fracker, W. H. Larrimer and S. A. Rohwer of Washington, D. C., were present.

After a short address by the president, E. L. Chambers, a report was presented by the representatives on the National Plant Board concerning the National Plant Board meeting held in New Orleans. Dr. L. A. Strong, speaking on "Domestic Quarantines, What of their future?" reported the curtailment of work due to lack of funds and the necessity of checking financial return against expenditures.

Mr. Wallace opened the discussion on "The advisability or inadvisability of revoking or revising Quarantine No. 43 on account of the European corn borer." The subject was further discussed by Dr. Strong, Professor Dean, Mr. Sullivan, Mr. Ellenwood, Mr. Glenn, Mr. Ruggles and Mr. Rohwer. The following resolution was passed: "Be it also resolved that since Congress has failed to comply with the request of the Secretary of Agriculture to appropriate adequate funds to maintain an efficient European corn borer quarantine, that the Central Plant Board go on record as not favoring the expenditure of funds on an inefficient quarantine such as a paper quarantine would be."

After a discussion opened by Mr. Ellenwood regarding Quarantine No. 48 on account of the Japanese beetle, the Central Plant Board passed a motion "favoring the continuance of the Federal Domestic Japanese Beetle Quarantine No. 48."

Following a discussion of Quarantine No. 63 on account of the White Pine blister rust by Mr. Ruggles, Professor Dean, Dr. Strong, Mr. Glenn and Mr. Fracker, the Board went on record as recommending the retention of Federal blister rust regulations with ample revisions.

After some discussion on Quarantine No. 62 relating to Narcissus bulb pests it was recommended that the domestic quarantine be dropped.

Dr. H. C. Young, Chief of Botany in the Ohio Agricultural Station at Wooster led a discussion on state quarantines dealing with plant diseases.

The remainder of the session was devoted to minor inspection problems and to the report of committees and other matters of business.

REPORT OF THE WESTERN PLANT QUARANTINE BOARD

By A. C. FLEURY, *Secretary, Sacramento, California*

The Fourteenth Annual Conference of the Western Plant Quarantine Board was held at Bozeman, Montana, June 9th and 10th, 1932. Every courtesy to make this conference a success was extended by Mr. A. H. Safford, Montana Commissioner of Agriculture, Labor and Industry, and Mr. George L. Knight, Chief, Montana Division of Horticulture.

We were particularly honored and benefited by having with us on our program Mr. Lee A. Strong, Chief of the Federal Bureau of Plant Quarantine, who spoke on "Observations on the Present Status of Plant Quarantine Enforcement;" Mr. Wm. C.

Wood, Superintendent, Division of Classification, Post Office Department, who read a paper on "The Status of State Quarantines under the Postal Regulations Pertaining to Plants and Plant Products;" Mr. W. W. Wood, Assistant Plant Quarantine Inspector with the U. S. Bureau of Plant Quarantine, who gave a talk on "New Developments Along the Northern Border;" and Mr. E. Coppel Rivas of the Department of Agriculture of the Republic of Mexico, who spoke on the Mexican fruit fly situation in Mexico and the efforts now being directed towards the control or eradication of that pest.

A number of subjects of interest to the western states were discussed as follows:

(1) The alfalfa weevil quarantines now maintained by a number of the states was reviewed and a special committee was appointed to draw up recommendations covering possible justifiable modification in the restrictions enforced by some of the states. Later in the meeting this committee submitted a recommendation that all states comprising the Western Plant Quarantine Board modify their alfalfa weevil quarantine as regards the movement of fruits, vegetables, household goods, farm machinery and nursery stock. It was pointed out that most of the difficulties connected with the alfalfa meal situation had been clarified by practically all states now admitting meal when shipped from approved mills under proper safeguards.

(2). The potato tuber moth quarantine regulations of several of the states were discussed and it was recommended that those states maintaining such quarantines uniformly accept vacuum fumigation of potatoes as adequate treatment for elimination of tuber moth.

(3). The committee appointed to report on black walnut canker was continued for another year in order to permit them to gather more information. This same committee recommended that those western states now having a commercial or potential pecan industry take the necessary quarantine action to protect this industry against the introduction of pecan nut case bearer, the pecan leaf case bearer and other serious nut tree insects not now occurring in the west.

(4). The black locust borer was a subject of considerable discussion. It was pointed out that Idaho has placed a quarantine against this insect and it was recommended that those western states having valuable locust plantings and free from that pest should take like quarantine action.

(5). The subject of possible pest introduction through the means of rice straw and other plant material as packing from foreign countries was again reviewed and the Board again expressed itself as feeling that federal quarantine action should be taken to meet this situation.

(6). Much interest was shown by all of the states in presenting and reviewing the several pest treatment methods which have been developed during the previous year. Atmospheric fumigation with hydrocyanic acid gas for thrips on citrus fruits and vacuum fumigation with hydrocyanic acid for mealybug on persimmon fruits to meet Hawaiian regulations; vacuum fumigation of potatoes for tuber moth; the use of liquid insecticides as a dip for sour limes from Mexico infested with scale insects; the injection of various liquid insecticides under fumigation for freeing date palm offshoots from Marlatt scale; thermal treatment of pears for mealybug and all fruits and vegetables as a Mediterranean fruit fly preparedness program; and a review of the experiments under way on the treatment of bulbs with ethylene dichloride and carbon tetrachloride were discussed.

(7). The matter of apiary inspection, particularly with regard to honey certification, was discussed and it was finally recommended that the Board defer any definite

action on the matter of honey certification until such time as more definite information is had by a committee appointed for that purpose from the Bureau of Bee Culture in Washington.

Among the important resolutions adopted were the following:

(1). Requesting the Secretary of Agriculture to make provision for a systematic and basic investigation for the control or eradication of important weed species and provide for a correlation of all weed control activities within the United States.

(2). Requesting the U. S. Bureau of Plant Quarantine to call an official hearing in the near future to consider the promulgation of a federal quarantine to restrict the use of plant material as packing from foreign countries.

(3). Requesting the Secretary of Agriculture to provide for more complete enforcement of the Lacey Act directed against the introduction of injurious bird and mammal species by designating maritime port and border inspectors of the Federal Bureau of Plant Quarantine as enforcing officers of that act.

In addition to the above resolutions the following recommendations and matters were called to the attention of the National Plant Board:

(1). The desirability of having such changes made by the Post Office Department in the Postal Laws and Regulations as may be necessary to make parcel post shipments of plants and plant products amenable to the quarantine regulations of the destination state.

(2). The desirability of the U. S. Bureau of Plant Quarantine acting as the central agency to prepare a master copy of an index or schedule of plant quarantine laws and regulations of each of the states and the federal domestic quarantines for the benefit of common carrier transportation agents, with the understanding that the printing and distribution to agents of such an index shall be handled by some agency to be designated by the transportation companies, and for the U. S. Bureau of Plant Quarantine to act in a similar capacity in the case of any changes or revisions of such quarantines. This proposal originally came from representatives of the transportation companies in the west with the idea that such index or schedule should be briefed and prepared in a way that it could be readily and effectively used by transportation agents by having one page for each state on which would be listed in alphabetical order the commodities restricted entry by such state, followed by a very brief statement as to the area quarantined against and as to whether that commodity was embargoed or admitted subject to certification, treatment, etc.

The officers elected for the ensuing year are George L. Knight of Montana, Chairman; Dr. F. E. Stephens of Utah, Vice-Chairman; A. C. Fleury of California, Secretary-Treasurer; and A. C. Fleury of California to serve with George G. Schweis of Nevada as a representative to the National Plant Board.

The next meeting of the Western Plant Quarantine Board was set for some time in June, to be held at Salt Lake City, Utah.

Wednesday Afternoon Session, December 28, 1932

VAPOR-HEAT TREATMENT FOR THE CONTROL OF BULB PESTS AND ITS EFFECT UPON THE GROWTH OF NARCISSUS BULBS[1]

By F. J. Spruijt, *Assistant Entomologist*, and F. S. Blanton, *Junior Entomologist, Division of Truck Crop and Garden Insects, Bureau of Entomology, U. S. Department of Agriculture*

Abstract

Vapor heat may be employed for the control of the bulb flies. Even the lowest temperature (110° F.) with a short time duration (three hours) was found to be ample for the control of both the larvae and pupae of Eumerus. There are indications that the Narcissus bulb nematode, *Tylenchus dipsaci* Kuhn., may be killed by this method without injury to the plants. The stimulating effect upon the growth, due to a moderate treatment, is expressed in the considerable weight increase of field-grown stock, and in most cases the bulbs treated at the higher temperatures were as good as or better than the untreated checks. Bulbs that were forced in a greenhouse after being submitted to a vapor treatment at 120° F. for two hours produced flowers equal to those of untreated checks. At lower temperatures the flowering date would sometimes be slightly advanced, but not enough to be of commercial importance. The foliage was not injured by this method of treatment.

The vapor-heat treatment was first applied to narcissus bulbs during the winter of 1929-30 by E. G. Hume in Orlando, Fla., under the direction of A. C. Baker, of the Bureau of Entomology. The initial treatments of Paper White and Chinese Sacred Narcissus and of Amaryllis bulbs were made early in January, 1930. As pointed out by Latta,[2] the use of saturated heat for the control of insects was suggested by D. L. Crawford as early as 1913, when he demonstrated that hot air of high moisture content would kill the eggs and larvae of the Mexican fruit fly, (*Anastrepha ludens* Loew) in citrus fruits without being detrimental to the fruit. During the Mediterranean fruit fly campaign of 1929-30 in Florida, A. C. Baker applied and developed this method in connection with the treatment of citrus fruits and it was given commercial application by L. A. Hawkins, of the Bureau of Plant Quarantine.

[1]The portions of this work dealing with the effect of the vapor-heat treatment against the bulb nematode, *Tylenchus dipsaci*, were done in cooperation with the Division of Nematology, Bureau of Plant Industry, U. S. Department of Agriculture. The writers wish to acknowledge particularly the assistance rendered by Gerald Thorne and Edna M. Buhrer in making the examinations of all nematode infested material treated in 1931 and 1932.

[2]Latta, Randall. The vapor-heat treatment as applied to the control of Narcissus pests. Jour. Econ. Ent. 25: 1020-1026. 1932.

Because of the success in Florida of the treatment of citrus fruits and especially on account of the preliminary indications obtained in the treatment of Paper Whites and other bulbs by Mr. Hume, vapor-heat equipment was installed in two bulb-growing centers, one in the State of Washington in the Northwest and one on Long Island in the East. The equipment installed was essentially the same as that originally utilized in Florida and has been described by Latta,[2] Hawkins,[3] and Mackie.[4] The installation at Babylon, Long Island, was completed late in the season of 1930 and a series of preliminary trials, the results of which are not given here, were hurriedly made to determine its possibilities.

EFFECT OF THE TREATMENT ON EUMERUS LARVAE AND PUPAE.—In September, 1931, a more extensive series of treatments were made at Babylon as follows: At 110° F. for 3, 4, 5, and 6 hours; at 111° for 3, 4, and 5 hours; at 112° and 113° for 2, 3, and 4 hours; at 114° for 1, 2, and 3 hours; and at 115°, 118°, and 120° for 1 and 2 hours. In each of these tests 75 healthy Narcissus bulbs of each of five varieties were treated. In addition to these healthy bulbs, bulbs containing large numbers of Eumerus larvae were included in the various lots treated. Twenty or more Eumerus pupae exposed in Petri dishes were also included to determine the effect of the heat upon their emergence. After treatment 50 bulbs from each lot of healthy bulbs were planted in the field and 25 were planted in flats and later forced in the greenhouse during the winter. The results of these tests are presented in Table 1. The fact that 100 per cent mortality was obtained in all cases shows that adequate control of the immature stages of *Eumerus* sp. can be obtained by vapor-heat treatment at 110° F. for three hours.

EFFECT OF THE TREATMENT ON THE BULB NEMATODE.—Since it is the common contention among bulb growers, as well as among some research workers connected with the narcissus-bulb industry, that the so-called eelworm disease is one of the more important problems in the production of Narcissus, observations on the effect of the vapor-heat treatment on the bulb nematode, *Tylenchus dipsaci* Kuhn, were included in these investigations. Since the killing effect of vapor-heat on Eumerus larvae and pupae was found to be adequate at the lower temperatures used, and since, as will be shown later, the tolerance of the Narcissus bulb to the vapor heat seemed to lie at a much higher temperature, the thermal death point of the bulb nematode should be looked for in the higher temperatures. It was believed, therefore, that the deter-

[3]Hawkins, L. A. Sterilization of citrus fruit by heat. Texas Citri. 9: 21–22. 1932.
[4]Mackie, D. B. Heat treatments of California fruits from the standpoint of compatibility of the Florida process. Calif. Dept. Agr. Mo. Bul. 20: 211–218. 1931.

TABLE 1. EFFECT OF VAPOR-HEAT TREATMENT OF NARCISSUS BULBS UPON THE IMMATURE STAGES OF EUMERUS SPP. AND THE WEIGHT INCREASE OF THE BULBS

Treatment		King Alfred bulbs						Glory of Sassenheim bulbs					
Temperature	Duration	Mortality of Eumerus larvae and pupae[1]	Weight of bulbs When planted		Weight of bulbs When dug		Weight increase	Mortality of Eumerus larvae and pupae[1]	Weight of bulbs When planted		Weight of bulbs When dug		Weight increase
°F.	Hours	Per cent	Pounds	Ounces	Pounds	Ounces	Per cent	Per cent	Pounds	Ounces	Pounds	Ounces	Per cent
110	3	100	4	14	10	7	114.1	100	2	12	6	3	125.0
	4	100	5	2	10	6	102.4	100	3	11	8	8	130.5
	5	100	5	4	10	2	95.1	100	3	8	8	8	142.9
	6	100	4	12	9	11	103.9	100	3	9	8	1	126.3
111	3	100	4	2	9	7	128.9	100	3	11	7	9	105.1
	4	100	4	1	8	0	98.4	100	3	11	7	9	105.1
	5	100	4	9	9	12	113.7	100	3	1	7	0	128.6
112	2	100	4	7	9	10	131.0	100	3	11	8	6	127.1
	3	100	4	9	9	3	115.1	100	3	13	8	10	126.2
	4	100	4	10	9	6	102.7	100	4	6	9	0	105.7
113	2	100	4	10	10	0	134.4	100	4	0	8	13	120.3
	3	100	4	7	8	15	101.4	100	4	5	9	0	108.7
	4	100	4	12	9	8	100.0	100	4	5	9	3	113.0
114	1	100	5	11	10	13	90.1	100	3	14	8	7	117.7
	2	100	5	0	10	4	105.0	100	4	4	9	6	120.6
	3	100	5	1	10	2	100.0	100	4	0	8	9	114.1
115	1	100	4	12	10	4	115.8	100	4	5	9	10	123.2
	2	100	4	13	10	4	113.0	100	3	13	8	5	118.0
118	1	100	5	0	9	10	92.5	100	4	14	10	1	106.4
	2	100	5	2	9	13	91.5	100	5	4	10	4	95.2
120	1	100	5	0	9	8	90.0	100	5	2	9	11	89.0
	2	100	5	2	10	0	95.1	100	4	14	9	6	92.3
Check		—	10	3	19	11	93.3	—	5	0	9	15	98.8

[1]In all cases 20 or more Eumerus pupae and many hundred Eumerus larvae were subjected to the treatment.

mination of the temperature lethal to *Tylenchus dipsaci* should be the guiding factor in further investigations.

Experiments in 1931.—The first samples used in the experiments conducted in 1931 were dried and shriveled bulbs that had been rogued out

TABLE 2. EFFECT OF VAPOR-HEAT TTEATMENT ON THE BULB NEMATODE, *Tylenchus dipsaci*, SEPTEMBER, 1931[1]

Treatment Temperature °*F.*	Duration *Hours*	Number of nematodes found	Condition of nematodes
110	3	Several thousand	Mostly active
	3	Several hundred	Mostly active
	4	Several hundred	Mostly active
	4	Several hundred	About two-thirds active
	5	Many thousand	Mostly active
	5	Several hundred	About 50 per cent active
	6	Several hundred	About 50 per cent active
	6	Several hundred	Mostly active
111	3	Many thousand	Mostly active
	3	Several hundred	Mostly active
	4	Many thousand	Mostly active
	4	Several thousand	Mostly active
	5	Many thousand	Mostly active
	5	Several hundred	Mostly active
112	2	Several thousand	Mostly active
	2	Several thousand	Mostly active
	3	Many thousand	Mostly active
	3	Several thousand	Mostly active
	4	Many thousand	Mostly active
	4	Several hundred	Mostly active
113	2	Several hundred	Mostly active
	2	Several hundred	Mostly active
	3	Several thousand	11 of 50 active
	3	Several hundred	11 of 50 active
	4	Several hundred	All active
	4	Several hundred	About 50 per cent active
114	1	Several thousand	About 50 per cent active
	1	Several hundred	Mostly active
	2	Several thousand	Mostly active
	2	Several thousand	Mostly active
	3	A few hundred	12 of 50 active
	3	Several thousand	About 50 per cent active
115	1	Several thousand	Mostly active
	1	Several thousand	Mostly active
	2	Many thousand	Mostly active
	2	Several hundred	Mostly active
118	1	Many thousand	Mostly active
	2	Many thousand	Mostly active
120	1	Several hundred	8 of 50 active
	2	Many thousand	7 of 50 active

[1]Examinations were made by Gerald Thorne.

of commercial plantings early in the growing season. Though heavily infested with nematodes, these bulbs were dug prematurely and had been dry for six months prior to treatment, and it is believed that the nematodes present may have gone into a dormant and therefore more resistant stage of existence. Mr. Gerald Throne, who examined the treated bulbs, reported finding great numbers of *Tylenchus dipsaci* in the pre-adult stage, the most resistant and dormant stage in the life cycle of this nematode. This condition may account for the different results obtained in the two successive years of treating nematode material, as is pointed out in the subsequent discussion.

As indicated in Table 2, exposures of as long as six hours were given in the treatments at 110° F. while in the treatments at 115°, 118°, and 120° F. the times of exposure were reduced to one and two hours. Samples treated for one and two hours at 120° F. showed 16 and 14 per cent revival, respectively Where any doubt existed as to their mortality, 50 of the apparently dead but sound-looking specimens of nematodes were left overnight in a moist chamber at approximately 22° C. From these treatments it was concluded that a 2-hour treatment is too short to give satisfactory results, even at the higher temperatures.

Experiments in 1932.—After the uninfested treated bulbs had been grown in the field and their weight increase had been calculated, no harmful effects of the treatment could be noticed; so in the late summer of 1932 treatments were given at higher temperatures and the time of exposure was lengthened. The nematode-infested bulbs for these treatments were dug in the field during August, 1932, together with the general plantings of bulbs In contrast to the material used in 1931, these bulbs were fresh and comparatively green, more like bulbs that the commercial bulb grower would have to handle Following the treatments examinations for living nematodes were made by Miss Buhrer. In only four cases, at 112° F for four and six hours and at 113° F. for three and five hours, were living nematodes found. (Table 3.) These figures apply to *Tylenchus dipsaci*. Living *Cephalobus* sp.[5] were found in bulbs exposed at 115° F. for ten hours and at 118° F. for three hours.

Effect of Treatment on the Weight Increase of Bulbs Subsequently Grown in the Field.—During the spring of 1932 field observations were made to determine the growing and flowering conditions of the bulbs that had been subjected to the various vapor-heat

[5]Where nemic forms are encountered in the examination of narcissus bulbs, the species of nematode present should be determined by a nematologist. Cephalobus may enter weakened bulbs or be associated with and follow Tylenchus, but according to present knowledge it is a weakness parasite or saprophytic in behavior.

TABLE 3. EFFECT OF VAPOR-HEAT TREATMENT ON THE BULB NEMATODE, *Tylenchus dipsaci*, SEPTEMBER, 1932[1]

Treatment Temperature °F	Duration Hours	Number of bulbs in lot	Number and portion of bulbs examined	Number and condition of nematodes found
112	4	23	1 in center	Numerous, one-half of them revived, but died in 18 hours
	5	9	1 in center, 1 in side	Fair number, all dead
	6	6	1 near center	Numerous, a few alive
	8	9	1 near center	Few, all dead
	12	12	2 in centers	Few, all dead
113	3	3	1 in center	Few, 5 out of 22 alive
	4	4	½ of 1	Few, all dead
	5	3	3	Few, 3 out of 25 alive
	6	3	3	Few, all dead
	7	4	4	Few, all dead
	8	2	1 in center	Fair number, all dead
	9	5	5	Few, all dead
	10	3	1 in center	Numerous, all dead
	11	3	2 near centers	Numerous, all dead
	12	3	1 near center	Fair number, all dead
114	3	7	1 near center	None found
	4	3	1 near center	Few, all dead
	5	4	1 near center	None found
	6	5	1 near top	Fair number, all dead
	7	5	1 near center	Fair number, all dead
	8	4	2 near centers	None found
	9	5	1 entire	Few, all dead
	10	3	1 near center	Few, all dead
	11	5	2 in centers	None found
	12	5	1 in center	Numerous, all dead
115	3	6	1 in center	Few, all dead
	4	4	1 in center	Very few, all dead
	5	4	1 in center	Very few, all dead
	6	3	1 in center	Numerous, all dead
	7	3	1 in center	Few, all dead
	8	4	1 in center	None found
	9	4	2 in centers	None found
	10	6	2 in centers	Numerous, all dead[2]
	11	7	1 near center	Numerous, all dead
	12	4	2 near centers	Few, all dead
116	3	3	2 near centers	Very few, all dead
	4	3	1 in center	Numerous, all dead
117	3	4	2 in centers	Fair number, all dead
118	2	3	2 in centers	Numerous, all dead
	3	4	1 in center	Numerous, all dead[3]
	4	3	1 in center	Numerous, all dead
	5	4	1 in center	Fair number, all dead
119	2	3	1 in center	Numerous, all dead
	3	5	1 in center	Numerous, all dead
120.	2	3	2 in centers	Numerous, all dead
	3	2	1 in center	Numerous, all dead

[1]Examinations were made by Miss E. M. Buhrer. Code used as follows: Few = 1 to 30 specimens; fair number = 30 to 60 specimens; numerous = more than 60 specimens.
[2]Many Cephalobus alive. [3]36 Cephalobus alive.

treatments. No damage to the flowers or foliage was noticed in any of the stock treated in the autumn of 1931. After the bulbs had been harvested, cleaned, and cured according to common practice, the percentage weight increase was calculated for the two commercial Narcissus varieties, King Alfred and Glory of Sassenheim. (Table 1.)

For the King Alfred variety the check plot (untreated bulbs) shows an increase of 93.3 per cent. Four treatments did not give this increase; at 114° F. for one hour, at 118° F. for one and two hours, and at 120° F. for one hour. The weight increases after these treatments were 90.1, 92.5, 91.5, and 90.0 per cent, respectively, or an average of 2.3 per cent below that of the check. On the other hand, the other 18 treatments gave increases in weight over the check from 1.8 per cent (at 120° F. for two hours) to 41.1 per cent (at 113° F. for two hours).

For the Glory of Sassenheim variety the weight increase of the check (untreated) bulbs amounted to 98.8 per cent. Three treatments fell short of this mark, at 118° F. for two hours and at 120° F. for one and two hours. The increases were 95.2, 89.0, and 92.3 per cent, respectively, or an average of 6.6 per cent below the check Nineteen of the treatments in this series showed an increase in weight over the check of from 6.3 per cent (at 111° F. for three hours) to 44.1 per cent (at 110° F. for five hours). The Long Island bulb growers consider a 90 per cent weight increase in their harvest of trumpet daffodils to be very satisfactory.

Although the foregoing tables do not show conclusively what temperatures and time durations are most suitable for a given variety, the indications are that tolerance to the vapor-heat treatment is much greater than that to the hot-water treatment, since no detrimental effects were evident. There is a further indication that in the treatments at the lower temperatures and for moderate time periods a decided stimulation in growth is obtained.

Effect of Vapor-Heat Treatment Upon Flowering in the Greenhouse.—In the 1931 experiments samples of 25 bulbs from each treated lot were planted in flats and later forced in a greenhouse according to commercial practice. Measurements were made of stem length, diameter of perianth, and width of trumpet. The dates of blooming, number of flowers, and the condition of the foliage were recorded.

The treated stock of King Alfred bulbs was, on the average, from one to six days later in blooming, especially after 80 per cent of the flowers had been harvested. The results for the treatments at 110° and 111° F. for three hours were found to run closely parallel to the checks and those for the treatment at 112° F. for two hours were only a little behind the checks.

The Glory of Sassenheim stock treated at the lower temperatures was a little better than the untreated checks. When the temperature of treatment was above 112° F. there was a tendency for the flowering to be delayed for two or three days. The exposure to 110° F. for five hours showed the best results, with 3-hour and 4-hour exposures at the same temperature following in the order named. Bulbs treated at 110° F. for five hours came into bloom approximately four days ahead of those treated at 111° F. for the same length of time.

No appreciable difference was noted in the size of flowers or in length of flower stems of either variety as a result of the various treatments. The foliage of both varieties was very good and especially heavy in Sassenheim after all the treatments.

SUMMARY.—The vapor-heat treatments can be satisfactorily employed for the control of the bulb flies (*Eumerus* sp.) in dormant narcissus bulbs. Even the moderate exposure at 110° F. for three hours is sufficient to control the immature forms of these pests.

There are good indications that this method of heat treatment may be successfully adapted to the control of the bulb nematode in narcissus planting stock with little, if any, injurious effect. When the 1932 season's treated bulbs have been dug and weighed, it is hoped that this point may be cleared up.

From the information derived from the 1931 treatments it is believed that the period of treatment may be lengthened without detrimental effect on field-grown stock.

At the lower temperatures the treatment results in a stimulation of growth, with a perceptible weight increase in field-grown stock. Bulbs may be successfully forced after such treatments and blooming occurs at a somewhat earlier date.

No injury to foliage by this method has been observed, even at the higher temperatures or by the longer periods of exposure.

MR. H. H DARBY commented that applying an apparently only partially effective heat treatment to living larvae may cause sterility of the adult even when the larvae apparently survive and pupate without injury. He stated that these results were secured in experimental work carried out at the Mexico City laboratory under the direction of Dr. A. C. Baker.

DISEASES THREATENING ORNAMENTAL AND FOREST TREES

By R. KENT BEATTIE, *Principal Pathologist, Division of Forest Pathology, Bureau of Plant Industry, U. S. Department of Agriculture*

In 1922 at your Boston meeting, Dr. W A Orton and the writer[1] presented to the American Association of Economic Entomologists in joint session with the American Phytopathological Society, some of the biological principles underlying the plant quarantine measures which the members of your organization assist in establishing and enforcing.

At that time, among other things, we called to your attention: (1) The disturbance of biological equilibrium that occurs when a plant parasite is transferred from one plant zone to another; (2) the impossibility of predicting from the behavior of a parasite in its native home what it may do when transferred to a new environment; and (3) the necessity of studying in their native habitats parasites that are incipient in or threaten entry into our country

THE DUTCH ELM DISEASE. For 13 years the Dutch elm disease, known to be caused by the fungus *Graphium ulmi* Schwarz, has been spreading through Europe killing European elms, until it is now found in Scandinavia, Poland, Germany, Holland, Belgium, England, Italy, Switzerland, Austria, and Roumania. In 1930 three trees affected with this disease were found in Cleveland and one in Cincinnati, Ohio. In 1931 four additional trees were found in Cleveland. All the disease found was eradicated No diseased trees were found in 1932, but this does not necessarily prove that the disease is not in this country. The symptoms of this disease, internal browning of the young wood and wilting of the foliage, are easily confused with those of several other elm diseases. Therefore, these diseases can not be distinguished from one another in the field but laboratory culture methods are necessary. A Dutch Elm Disease Laboratory was, therefore, established at Wooster, Ohio, in 1930 by the cooperation of the Bureau of Plant Industry and the Ohio Agricultural Experiment Station, with Mr Curtis May of the Ohio Station in charge At this laboratory all specimens received, whether from Ohio or elsewhere, with symptoms similar to those of the Dutch elm disease have been cultured to determine the causal organism. In 1930, 302 specimens were cultured; in 1931, 600; and in 1932, 453. In 1932 the specimens represented trees located in 19 different states. If funds permit, the station will be maintained and active watch for the Dutch elm disease will be continued.

[1]Orton, W. A., and R. Kent Beattie. The biological basis of foreign plant quarantines. Phytopathology 13: 295–306. July, 1923.

Thus far we have been unable to determine the method of introduction and of distant spread of the Dutch elm disease. The evidence indicates that it did not come into the United States on nursery stock. Solution of this problem probably must await opportunity to study the spread of this disease in Europe where already it is beyond control. Here, in its incipient stage, the disease must be eradicated.

Diseases with symptoms similar to those of the Dutch elm disease are caused by species of *Cephalosporium*, *Verticillium*, and *Sphaeropsis*.

LARCH CANKER —In 1927 the European larch canker, caused by *Dasyscypha willkommii*, was found in a private estate, now owned by a public institution, near Hamilton, Mass., and on another estate at Ipswich, Mass. The diseased trees were destroyed at Ipswich and the whole of the infected larch planting was destroyed at Hamilton. A considerable search has been made of the northeastern United States, but to date the disease has not been found at any other point. The search is being continued

Although this disease had been known and studied for many years in Europe, research conducted by Dr. Glenn G Hahn, of the Division of Forest Pathology, soon developed the fact that this part of the genus *Dasyscypha* was in great confusion and it has been necessary to make careful separation of this European and certain related American species. Dr. Hahn has determined that there are two native saprophytic species which have been confused with the introduced parasite and that the introduced one is the only one which causes larch canker

As a valuable by-product of this research, it has been determined that *Dasyscypha ellisiana*, normally saprophytic on species of pine in the eastern seaboard states and not known west of the Alleghenies, has become a parasite on Colorado Douglas fir introduced into Rhode Island. Since this is far outside of the range of this valuable tree, one can not predict the behavior of the fungus if it were carried to the West.

WOODGATE RUST.—The Woodgate rust was found in 1925 at Woodgate, N. Y., where it causes numerous galls on Scotch pines It occurs in other Scotch pine plantings in the western Adirondacks. The organism involved is a species of Peridermium closely akin to *Peridermium harknessii*, an abundant rust in our western states. Whether or not it is identical with that species is still a subject of discussion among mycologists. No rust like it is known to occur in Europe or Asia. Inoculation experiments have shown that several of our western and southern pines are susceptible, but lack of funds has prevented the studies necessary to determine its probable behavior in the field. No new infection localities have been noted recently.

RESINOSIS OF WHITE AND RED PINE.—A canker disease attacking the crown and upper roots of the red and the white pines in an alarming fashion and characterized by copious resin exudations has been found by Dr. H. H York,[2] of the University of Pennsylvania, in plantations at Norwich, Hemlock Lake, and Salamanca, N Y. The causal organism has not yet been determined and the source and distribution are not yet known The disease is known nowhere else in America or abroad, but our knowledge of root diseases of conifers is very fragmentary.

FIR NEEDLE BLIGHT —A fir needle blight, caused by *Rehmiellopsis bohemica*, is quite widespread in Europe The needles of the new growth become reddish and shrivel and then dark brown or black, and many cling to the twigs The trees appear as if injured by late frosts. A needle blight found at Hamilton, Mass, in 1931 and again in 1932 proves to be this disease It will be described by Dr. Alma M. Waterman and M A McKenzie, of the Division of Forest Pathology, in the January, 1933, number of Phytopathology.[3] This disease has also been found in three places at Augusta, Maine, and five places at Lake George, N. Y All the affected trees are relatively old and have been in place for a number of years. The source of the infection has not yet been traced.

THE STUDY OF INCIPIENT DISEASES -The diseases above mentioned seem yet to be present in the United States in very incipient form. They forcefully bring to our minds the necessity of discovering and studying such organisms when they are "rare" in our country. After a disease is fully established, its eradication is usually hopeless. It is true that in their incipient forms it is often impossible to determine certainly whether or not they present a real menace to our forests, but a few thousand dollars spent in research when a disease is new is in the nature of insurance against future catastrophe. If the investigation shows that the disease is not likely to do serious harm here, we should rejoice; if, on the contrary, it reveals a menace, early eradication measures can be undertaken.

The diseases discussed also present clearly the necessity of the study abroad of diseases incipient or likely to be introduced. It is utterly unsafe to study here the methods of distribution of the Dutch elm disease. The work should be done at once in England, across which country the disease is now marching.

[2]Anonymous. New disease on white and red pine. Journal of Forestry 30 (4): 505–506. April, 1932.

[3]Waterman, Alma M. and Malcolm, A. McKenzie. A disease of Colorado fir. Phytopathology 23:108–109. Jan. 1933.

Whether the fir needle blight is a menace to our extensive American balsam and white fir forests can best be determined by a search for information in the mountains of Europe

Such diseases also illustrate well the complications which are met in the control or eradication of an introduced disease The chestnut-blight organism, *Endothia parasitica*, had its saprophytic relatives and little could be done on the chestnut-blight problem until these closely related fungi could be easily distinguished.

Great complications were introduced into the work on the white pine blister rust by the discovery of a blister rust on western pinyon pine which also had a species of *Ribes* for alternate hosts, and intensive study alone solved the problem of their delimitation.

The larch canker problem is complicated by several species of *Dasyscypha* related to *D willkommii*

Search for the Dutch elm disease has revealed the presence of two or more other diseases with similar superficial symptoms but caused by entirely different fungi

Our ignorance of root diseases and the unusual difficulties attending their investigation make it particularly difficult to determine whether the resinosis discovered in New York State is native or introduced

For the solution of such problems and the discovery and eradication or control of such diseases, the pathologist, mycologist, and nursery inspector must cooperate, and it is only by means of such whole-hearted cooperation that menacing diseases can be discovered early and prevented from establishing themselves in America.

MR. BEATTIE further commented on a fungous disease found recently attacking Scotch, red, Virginia, and other pines in the eastern states. This fungus has been discovered at one point in Ohio, two places in Pennsylvania, and one locality in New Hampshire The fungus is possibly a Scleroderris and is identical with the one described as *Atropellis pinicola* which occurs on western white pine, sugar pine, and jack pine in the Pacific Northwest, but the organism has not previously been known in the East

The relationship between a fungus and an insect occurring on beech in Maine was also mentioned. The insect (*Cryptococcus fagi*) attacks the tree, and the fungus (*Nectria* sp.) kills the tree after the latter has been injured by the insect Sixty per cent of the beech in the maritime provinces of Canada are infected. The insect is present around Boston but the fungus is not known to have reached that State

THE LIMA BEAN SCAB SITUATION

By W. A. McCubbin, *Bureau of Plant Quarantine, Washington, D. C.*

ABSTRACT

Lima bean scab, due to the fungus *Elsinoe canavaliae*, is a disease confined to this host. It is probably endemic in the Central American and West Indian regions, and is not known to occur in the United States. Being a well specialized parasite the fungus does not seriously injure its host, the outstanding damage arising from disfigurement of the pods. The evidence points to inter-season carry-over on living plants and to spread by wind. Temperature and moisture relations in Cuba indicate that it might be troublesome in at least some of our lima bean areas. Its relation to a long winter and frost are unknown and these might be limiting factors in the north. Successful control by spraying requires numerous applications involving excessive cost. The chief danger of introduction lies in the discarded pods, which may reach our fields by way of garbage. Point-of-origin inspection and certification is unsatisfactory; it both throws out too much of the crop and yet allows considerable scab infection to remain. Importation of lima beans in the shelled condition under refrigeration in transit would assure adequate protection and is regarded as a commercial possibility.

Lima bean scab due to the fungus *Elsinoe canavaliae* was first recognized as a disease distinct from Anthracnose, the common pod-spotting trouble, by Dr. Anna E. Jenkins of the Bureau of Plant Industry in 1930, from beans collected the previous year in Cuba by Dr. S. C. Bruner, and from specimens taken from Cuban bean shipments at New York by inspectors of the Bureau of Plant Quarantine. A similar disease has been described on *Canavalia*, the horse or jackbean in Ceylon, Java and the Philippines. Field evidence and experiments in Cuba by Dr. Bruner indicate that the two diseases are not identical and that the lima bean scab is strictly confined to the lima bean group.

The scab disease is also known in Puerto Rico. Interceptions of scab have also been made by our port inspectors from Mexican lima beans coming from the region around Sinaloa. Recent studies by Miss Jenkins on herbarium material from various sources has disclosed scab on lima bean specimens originating in Guatemala (1890), Costa Rica (1894), Nicaragua (1903), and San Salvador (1925). It has been in Cuba since at least 1916. It would thus appear that the disease is of long standing and is widespread over the Central American and West Indian region.

During the period March 16–20, 1931, the writer visited Cuba to make field observations there, in the hope of getting more definite information on the pest status of this scab, particularly from the quarantine point of view. From what was there learned, as well as from the studies of Miss Jenkins, and from the work of Dr. Bruner in Cuba, it is possible to present some picture of the situation which is involved in this disease.

The fungus itself appears to be of well specialized type. As noted it is not known to occur on any other host in Cuba or elsewhere. Further it seems to be so happily adapted to its host that the latter is not seriously damaged— a significant indication of specialization. This high degree of specialization in both host and habit of life suggests at once the possibility that it may also be narrowly limited in other respects.

The fungus attacks the host parts superficially, causing shallow scab areas on the pods, similar smaller scab lesions on the stems and peduncles, and typical leaf-spot effects on the leaves. Apparently it exerts little toxic action beyond the area actually attacked, so that the plant may have a considerable amount of infection without suffering from leaf-fall, yellowing, or other general symptoms of debility With the plant's vital functions thus left intact, a pod may be covered by coalescent scab spots and still bear normal plump seeds within. There is no doubt that scab does lower the productiveness of the plant, but the most outstanding effect of the disease is the marked disfigurement of the pods by the conspicuous, red-bordered, grey-centered, blotches

There is every evidence that the spores copiously produced by these spots are wind-borne, and that air currents play a major role in spread. A field observed by the writer in Cuba had 80-90% of its pods infected, yet no beans had grown on that land or in the neighborhood for at least several years and the nearest lima beans were at least two miles distant The Cuban farmers also think the scab increases after every stormy period

Moisture conditions of course favor this scab. It may be thought that the high annual rainfall in Cuba provides a condition quite different from our comparatively dry summers, so that the disease would probably not thrive here But it must be remembered that the Cuban crop is grown in winter, during the dry season, when for the three months December, January and February the average monthly precipitation is around 2 inches, although the 10-year yearly average is 55 inches. We are also likely to misjudge the matter of temperature which during the crop period in Cuba has a mean of 74–75° F., a condition not markedly different from that prevailing in many parts of our country during the summer months.

Another feature of considerable importance in estimating the pest status of a disease is the manner of carry-over—the method by which the fungus bridges the interseason gap. The evidence in Cuba points to survival on living lima bean plants, either wild or escaped plants, those left intact by poor plowing, or old fields which have been left untouched during the summer. Such survival is understandable in a climate with but narrow seasonal variations.

Control by spraying must also be considered. From experiments conducted in Cuba by Dr. Bruner a reasonable degree of control was obtained only by means of numerous applications of spray or dust. It is questionable whether the two or three applications which our own bean industry might bear would give any adequate control of this disease.

A final interesting point in this disease, and one on which there is unfortunately no information, is its possible reaction to winter conditions above the frost line. Is it tied so definitely to its living host that it could not survive when that host perishes? Or could it, like many other fungi, pass the winter successfully on dead plant parts, debris, or in the soil? Is it capable of holding its own and surviving among the fungi of decay that rapidly invade every stricken plant? Is cold a limiting factor to the fungus itself? To these questions there are as yet no answers.

From this outline of the salient features of the disease we may pass to the inquiry as to its chances of entry into this country. It is well to note that from Puerto Rico and Cuba lima bean importation has for some years been restricted to the port of New York, and confined to the period December to March inclusive. This restriction has been established on account of the bean pod borer, *Maruca testulalis* which occurs in both islands. Entrance at New York in winter was conceded to the importers with the understanding that the imported lima beans would not be shipped south of Washington, D C , which stipulation has not been at all times adhered to, although it is believed that southern shipments have been small and few In Puerto Rico all beans are inspected and certified before leaving the island and in Cuba a similar service is given by the Cuban authorities, the shipments being sorted to remove scab as well as the pod borer.

In spite of these arrangements, however, Cuban beans continue to enter New York still containing a small percentage of scab, and since the fruit and vegetable quarantine relates to insects only, they have been allowed to enter there, reliance being placed on the winter season and the small chance of their moving south.

In the utilization of such beans the discarded pods of course constitute the real danger. They go out in garbage and may thus find their way to farm areas. During the year 1931 some attention was given to the garbage disposal systems of 5 Atlantic seaboard cities and three in California. In all cases except in Baltimore the methods of garbage disposal provided a channel whereby the scabbed pods might go out uncooked to trucking or farming districts. While the chances of establishment of the disease in this way may be small in some cases, there can

be no question of the reality of the danger in either eastern or western sections.

Is this lima bean scab already present in the United States? We are fortunately able to say with some degree of assurance that it does not appear to have yet established itself in our lima bean areas. This assurance is based not only on the absence of reports from the crop disease reporters of the Plant Disease Survey, but on two special surveys made during the summer of 1931. One of these, carried out in July and August by the Plant Disease Survey in cooperation with the Bureau of Plant Quarantine covered the eastern lima bean areas from New York to Florida, and during it lima beans were examined in fields, packing houses, and markets in 8 states (N. Y., N. J., Pa., Va., N. Car., S. Car., Ga., Fla.). No scab was found in any of the 100 localities visited. A similar survey was made in California in August of 1931 by the writer in cooperation with the California Department of Agriculture. In this survey 50 lima bean fields and 58 lots in the markets of 8 towns were examined in southern Clifornia without disclosing any trace of scab. Since the areas thus covered are thought to represent the territory most likely to be affected by introductions of the disease there is reasonable ground for assurance that we are still free from scab.

In view of this freedom we may venture to raise the question: What shall our future policy be in regard to this disease? Shall we aim to exclude it as an undesirable, or ignore it as something trivial?

Let us refer to the points already discussed which may be said to sum up what we know about the pest status of lima bean scab. It occurs on one host only, and that an important though not a major crop in this country. It does not cause excessive crop reduction but does disfigure the pods and thus greatly lessen their market value for sale in the pod. Successful control by spraying would promise to be expensive, but since the disease is wind-borne how could one man otherwise than by spraying protect himself against infection from a careless neighbor's field? There is hope that in the absence of inter-season living plants the disease could not maintain itself readily outside of regions where summer is virtually perpetual, but we do not know yet whether the fungus could not survive on dead plants. Similarly we are ignorant of what its behavior would be under northern winter conditions. In any case it is disturbing to note that the disease occurs in the Sinaloa region of Mexico which has climatic conditions almost identical with those of southern California. Further, the discarded pods which may carry the fungus by way of garbage channels to our fields constitute a danger that connot be ignored. Sorting out scab at the point of shipment reduces but does not

eliminate this danger. And while restriction of importation of beans from Cuba and Puerto Rico to the winter months and to the port of New York no doubt also tends to reduce this danger, no one could conclude that this arrangement provides a permanently safe procedure. In the west no such seasonal limitation exists on the bean importations from Mexico, although market and tariff considerations do discourage Mexican imports except when scarcity in California raises the price. In the west also there can be no reliance on winter conditions and the danger from garbage disposal is always present if scabby beans are on the market. In California also the points of greatest consumption of Mexican beans are in the midst of the large lima bean areas. Finally, if we add to the picture the fortunate fact that we seem to be yet free from scab, our summary of the pest status is as complete as we can at present make it.

Let us now examine the various lines of action that might be taken in the situation thus outlined

The first that comes to mind is of course an embargo, which would effectually solve the matter by excluding all lima beans from regions where scab is known or suspected to exist It must be pointed out, however, that it is not right or fair to use this peremptory method until all other less drastic measures are found to be inadequate.

Almost at the other extreme we find our present arrangement by which beans enter from Mexico without specific restriction, and are received from Cuba still containing after sorting appreciable percentages of scab. Continued acceptance of the risk involved in garbage disposal and shipments to the south from New York are to be considered as tantamount to eventual establishment of the disease

If we canvass the possibilities between these two unsatisfactory extremes, it is found that because of the superficial habit of the fungus it might be biologically acceptable to treat the pods with a fungicide before they are shipped. If such a procedure could be arranged to satisfy the technical requirements of safety, and was commercially feasible, it would provide an acceptable solution. In this system the sorting out of scab need only be carried out to the point required by market considerations.

At the suggestion of the Bureau of Plant Quarantine several small experimental shipments of scabby beans were treated in 1931 in Cuba with formaldehyde under the direction of Dr. Ernesto Sanchez, Chief of the Sanidad Vegetal there, and were then shipped to New York. These shipments were examined by a representative of the Bureau of Plant Quarantine on arrival and again after they had been held in cold

storage for 4 days. While their condition in general was not entirely satisfactory there were indications that with due modifications shipment might be made successfully after such treatment. A few culture tests made by Dr. Anna E. Jenkins from specimens in these shipments indicated that the fungus had been destroyed. However, this method has such outstanding practical disadvantages that it has not been carried further than these tentative efforts

Another proposal, equally sound biologically, involves shelling the beans at point of origin and importing only the shelled product Practically this method has several advantages It avoids treatment, for the danger from spores adherent to the beans is eliminated by cooking. The scabbed beans can be used since the fungus does not penetrate within the pod All inspection at either end may be dispensed with, the method promises to be also of value for the bean pod borer problem, shelling in the country of origin could be done cheaply by local labor; and freight and container charges would be lessened

From the protection point of view it would be possible to arrange for removal of the pods either before shipment or to allow the beans to enter under control, shelling and safe disposal of pods to be carried out under quarantine supervision While biologically acceptable this method of handling would limit entry to a few ports, impose a load of supervision on our quarantine organization involving considerably added cost, and would necessitate some organization by importers, as well as higher labor costs in shelling. Point-of-origin shelling is the preferable alternative. The beans could then enter without restriction at any port

However it is not yet established whether the shelled product can be shipped commercially in good condition and various features of this problem remain to be solved, such as temperature and moisture relations, aeration, type and size of container and the value of precooling.

These various points are now being investigated by Dr. L A. Hawkins of the Bureau of Plant Quarantine. If the technical difficulties in shipping can be overcome, the method of importing lima beans in the shelled condition would seem to provide adequate safety from this disease, and at the same time avoid the necessity for an embargo on the one hand, or on the other a continuation of the present unsatisfactory situation.

THE INSECTS AND DISEASES OF RHODODENDRON AND AZALEA

By RICHARD P WHITE,[1] *Research Specialist, Diseases of Ornamentals, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey*

It is the purpose of this paper to describe those insect pests and plant diseases of Rhododendron and Azalea which might come to the attention of the nursery inspector It is the hope that such a tabulation as follows, will better enable the inspector to fulfill his obligations to the nursery trade in the dissemination of practical and scientifically sound information pertaining to the control of these pests The brief symptomatic descriptions of the types of injury commonly found on these plants, with notes on the control of the insect or fungous pest, should in part, at least, fulfill the needs of the inspector Space does not permit detailed descriptions of the organisms concerned, or their habits, except where such information is necessary to clarify the control procedures.

INSECTS

1. LACE BUG* (*Stephanitis pyrioides* Scott on *Azalea* spp. and *S. rhododendri* Horv on *Rhododendron* spp.) (Pl. 27, A)—The azalea and rhododendron lace bugs cause similar injury on their hosts: a spotted or mottled grayish discoloration on the upper surface of the leaves with the lower disfigured by the blackish or brownish excrement, cast nymphal skins and brownish shields over the eggs which are inserted in the leaf tissue. Lace bugs are more severe on plants growing in the sun and are of little importance in shaded areas. They overwinter as eggs inserted in the leaf tissues of the evergreen types of azaleas and rhododendrons. The first brood appears in New Jersey the very last of May or during June. *Rhododendron ponticum* is not a favored host, but most other species and the hybrid varieties are very susceptible to injury. Lace bugs also occur on *Kalmia latifolia*, *Pieris japonica*, and *P. floribunda*.

Control: Contact insecticides as nicotine and soap[2] or a safe summer oil plus nicotine, particularly on azaleas where spider mites are also a

[1]Acknowledgment is made for assistance in preparing the first part of this paper to Dr. C. C. Hamilton, Associate Entomologist, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey. Journal Series paper of the New Jersey Agricultural Experiment Station, Department of Plant Pathology.

*Indicates Insect or Disease of major importance.

[2]For general nursery use sprays containing ½ per cent soap and free nicotine at dilutions of 1–2400 to 1–3000 are recommended. A safe summer oil is used at dilutions of 1–75 plus one pint of 50% free nicotine solution per 100 gallons of spray solution.

factor, every ten days during June and at wider time intervals during the remainder of the summer, directed toward the under surface of the leaves.

2. THRIPS* (*Thripidae*) On *Rhododendron* spp. and *Azaleae* spp. (Pl. 27, B)—Thrips are particularly severe on *R. ponticum* seedlings either in the greenhouse or in frames, and on *Azalea indica* and its many horticultural varieties, and *A. phoenecia* in the greenhouse. They cause a grayish-white mottling of the upper surface of the leaves, which is more diffuse or blotchy than that caused by the lace bug. On the lower surface a silvery appearance is given to the leaf with minute spots of black excrement.

Control: In frames outdoors, frequent applications of contact insecticides as nicotine and soap applied toward the under surface of the leaves. In greenhouses, particularly in grafting chambers, two applications of a contact dust insecticide.

3. SCALE (*Aspidiotus hederae* Vallot) (Pl. 27, C)—This oleander or ivy scale often occurs on leaves and twigs of older rhododendron plants, causing a yellow spotting of the foliage and if severe, a weakened growth. It is not to be considered, however, as a major pest of these plants.

Control: Spray with dormant oil sprays when the plants are completely dormant, preferably in late winter or early spring about two weeks before new growth starts.

4. MIDGE* (Undetermined)—A species of midge has caused considerable trouble in nurseries on *Rhododendron ponticum*, *R. maximum*, and hybrid varieties. It has also been found on native *R. maximum* in the Pocono mountains of Pennsylvania. These pests cause a spotting of the foliage, rolling of the leaf margins, and if numerous, a crippled, malformed, stunted terminal growth. The larvae are white, about 1/4 inch long when full grown and can be found in numbers during August in the curled margins of the infested leaves.

Control: Frequent applications of a contact insecticidal spray (nicotine-soap) have afforded practical control, under field conditions.

5. CRANBERRY ROOT WORM (*Rhabdopterus picipes* Oliv.) on *Rhododendrons* pp. (Pl. 27, E)—This pest causes very characteristic feeding injury on the younger foliage of rhododendrons, typically eating out holes in the shape of a crescent or with a sharp angle. They are night feeders, spending the day in the mulch at the base of the plants.

Control: Keep foliage covered with arsenate of lead from about June 15 to August 1.

6. ASIATIC BEETLES* on *Rhododendron* spp. and *Azalea* spp.—Typical foliage injury is produced by the Japanese beetle, (*Popillia japonica*

Newm.) on the younger foliage, which results in the skeletonizing of the leaves. The injury is frequently very severe in spots in the field, due to the gregarious habits of the beetles. They may be controlled by keeping the foliage covered with arsenate of lead during the beetle flight period.

The grub of the Japanese beetle, of the Asiatic Garden Beetle (*Autoserica castanea* Arr) and of the Asiatic beetle (*Phyllopertha orientalis* Waterh.) may cause considerable damage by feeding on the main roots and underground stems. Their activity at this point often results in girdling the roots and stems, followed by a yellowing of the foliage, wilting, and death of the plants

Control: Apply arsenate of lead to soil at rate of 1500 pounds per acre, worked into the upper four inches,

7. SPIDER MITES* (*Tetranychus telarius* L.) on *Azalea* spp.—Spider mites do not appear commonly on rhododendrons under field conditions. They may become a pest on these plants under greenhouse conditions on *R. ponticum* and hybrid varieties while in the grafting chambers. On Azalea spp. however, particularly certain varieties of *A. indica*, they may occur in abundance under field conditions, and are always a menace on these varieties when being forced for Christmas or Easter.

Control: A safe summer oil diluted 1-75 to which is added one pint of a 50% free nicotine solution to every 100 gallons of spray, and applied frequently to the lower surfaces of the leaves with at least 200 pounds pressure, has given good control under both greenhouse and field conditions. Frequent applications are absolutely necessary during the summer on such favored hosts as the variety Madame Petrick.

8. CLEAR WING (*Sesia rhododendri* Beut.) on *Rhododendron* spp. (Pl. 27, G.)--The adult moth appears in June and deposits its eggs in the bark. The larvae are about half grown in late August and reach full size late in October. They then appear as white grubs, with a brown head, about ½ to ¾ inch long. The injury they produce is usually apparent in September and early October, as a wilting, yellowing and death of stems and branches. The larvae burrow in wood just beneath the bark, pushing out borings as fine sawdust, usually a foot or more above ground but frequently at the soil level

Control: Prune out and burn dead or infested branches in the fall or winter.

9. STEM BORER (*Oberea myops* Hald.) on *Rhododendron* spp. and *Azalea* spp. (Pl. 27, F.)—Causes death of branches or entire plants of Rhododendron and Azalea spp. The adult beetles emerge in June and are present during June and July. The young larvae hatching from eggs deposited at the tips of the branches, bore down from the branch tips

in the center of the stem for about 12 to 15 inches, where they pass their first winter. The following summer they continue down the stem, pushing out borings through numerous holes as coarse sawdust. The full grown larvae are yellowish, about 1 inch long, and in the fall of the second year can be found near the base or crown of infested plants Before passing down to the base of the stem underground, or to the crown of collected plants, the main stem or branch is almost girdled about 4 to 6 inches above the soil level. Infested plants die during the autumn due to this girdling and are easily blown over by fall winds

Control· Destroy all parts of infested plants in the autumn by pulling and burning

10. WEEVILS* (*Brachyrhinus sulcatus* (Fab.) L.) On *Rhododendron* spp.) (Pl. 27, D.)—These weevils occur frequently on species and varieties of rhododendron, eating out small holes on the edges of leaves and less frequently in the center If numerous they often destroy the entire leaf except the midrib which is not touched They are nocturnal feeders and in the day can be found under the mulch at the base of the plant The larvae feed on the roots during the autumn and spring The adults emerge from about the middle of June to the last of July and feed on the foliage the remainder of the season and late into the fall. Two other species of Brachyrhinus have been reported on rhododendron, but it is felt that *B sulcatus* is the species doing most if not all the damage in this country

Control: Lead the soil as for the control of the Asiatic garden beetle, and if necessary dust the plants with calcium arsenate-hydrated lime dust, or use poisoned bran or apple baits, such as "Go-West"

11. LEAF SKELETONIZER (*Gracilaria azaleella* Brants) On *Azalea* spp. —Eggs are laid by the adult moth on the under surface of leaves close to the midrib. The larvae turn under the tip of the leaf or the margin

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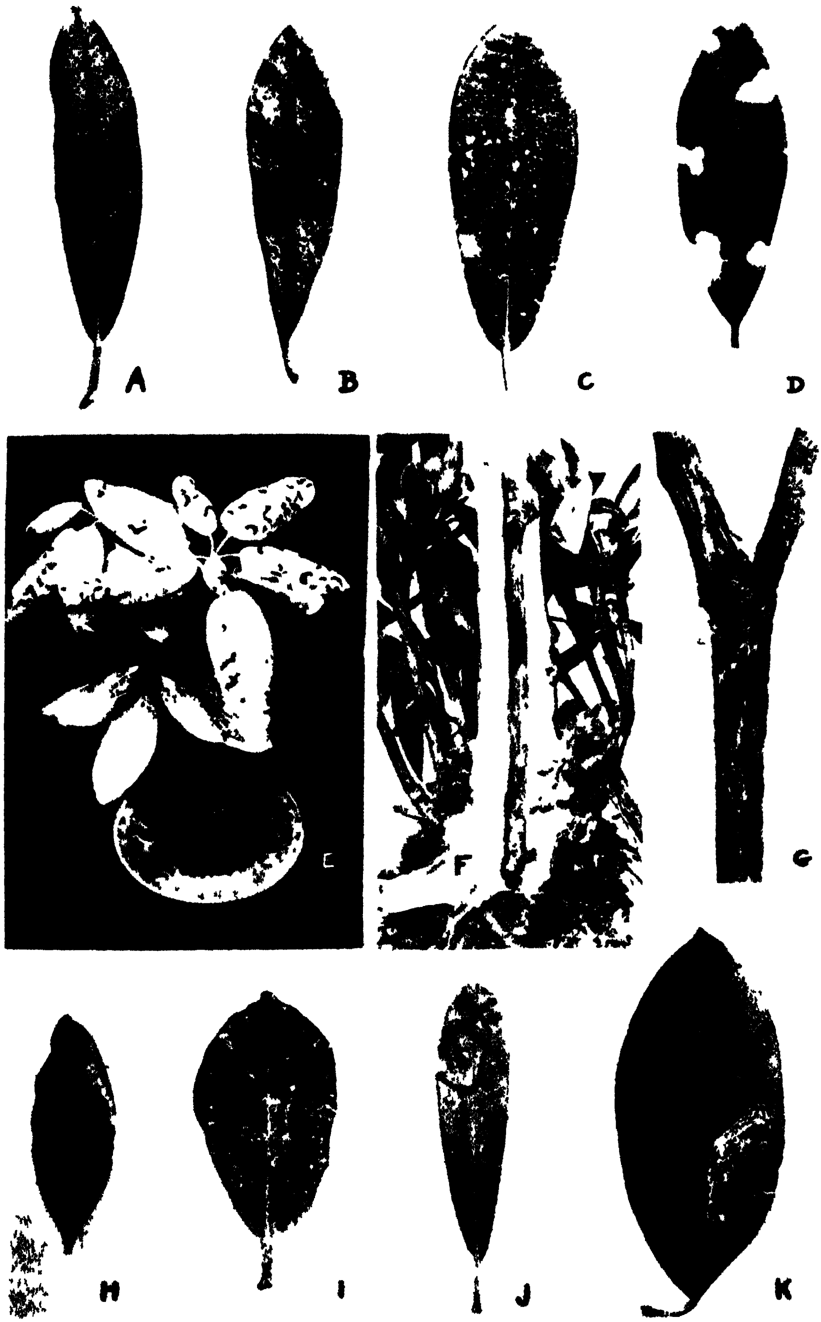
Plate 27

A. Lace bug injury on *R. maximum*.
B. Thrips injury on *R. ponticum*.
C. Ivy scale on *Rh. catawbiense* hybrid.
D. Weevil injury on *R. catawbiense* hybrid.
E. Cranberry root worm injury on *R. catawbiense* hybrid.
F. Stem borer on *R. catawbiense* hybrid.
G. Clear wing on *R. maximum*.
H. *Cercospora rhododendri* on *R. ponticum*.
I. *Cercospora rhododendri* on *R. catawbiense* hybrid.
J. *Pestalotia macroticha* on *R. maximum*.
K. Leaf infections of *Phytophthora cactorum* on *R. catawbiense* hybrid.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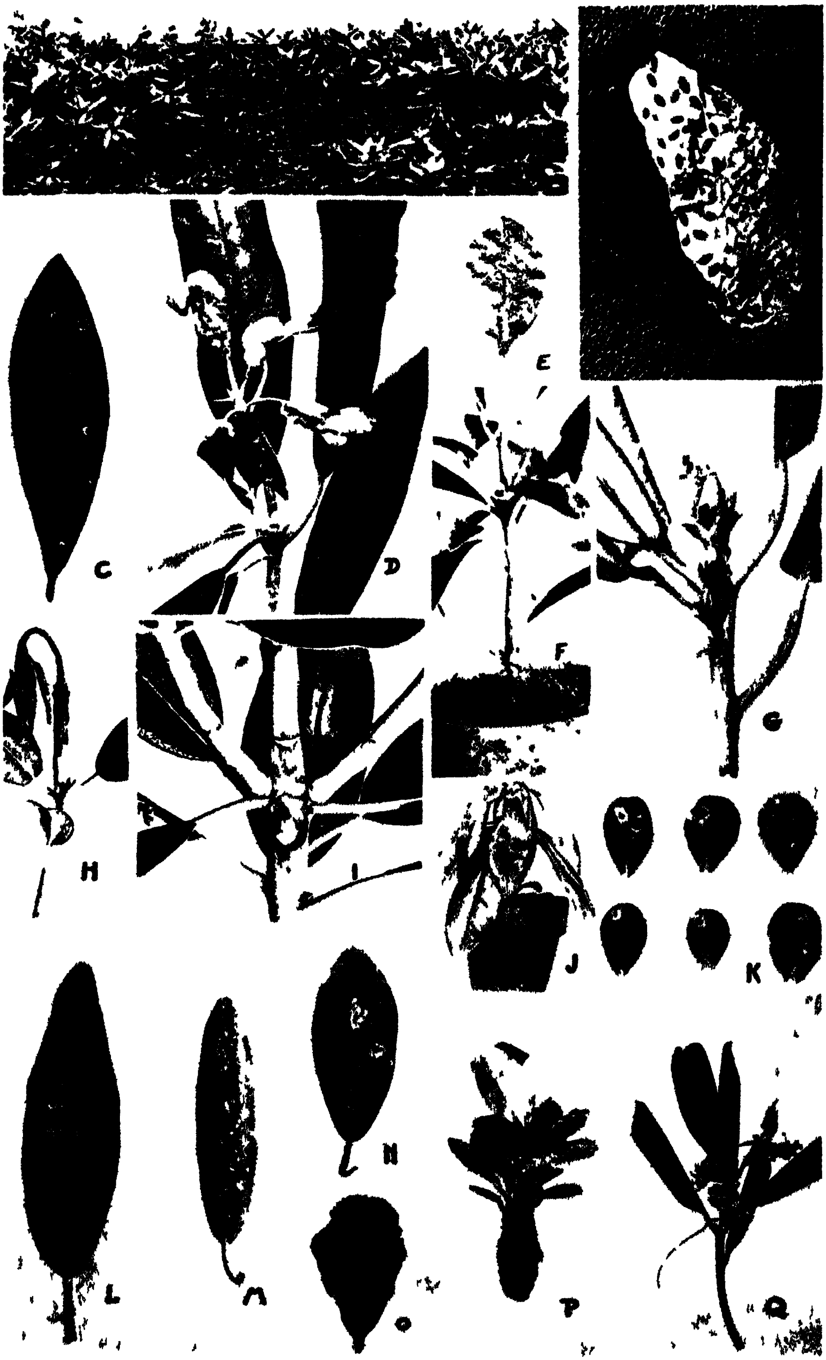
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and fasten it down, feeding on the protected portion of the lower epidermis. This causes the leaf to wither and die.

Control. Hand pick in greenhouses if not numerous. If numerous fumigate with cyanide. In the field, if severe infestations are encountered, spray with arsenate of lead.

12. Two other insect pests have been noted on rhododendrons but are of minor importance. Felt found the Ambrosia beetle, *Corthylus punctatissimus*, working in stems of rhododendron in New York City and this pest has once been observed in nursery grown plants. The azalea scale (*Eriococcus azaleae* Comst.) occurring on the bark of rhododendrons and azaleas is also of minor importance.

DISEASES

Of Leaves

13. CERCOSPORA LEAF SPOT* (*Cercospora rhododendri* Mar. and Verpl.) (Pl. 27, H, I.)—This disease is characterized by the formation of angular dark brown spots on leaves of *R. ponticum*, with a grayish down or pubescence in the center of the spots on the upper surface due to the sporulation of the organism. On certain hybrid varieties, these spots are similar, although the center of the spot may become silvery white, due to the lifting of the epidermis. Most severe on lower foliage of young stock.

Control. Bordeaux mixture, 2-2-50 at 10 to 14 day intervals during the growing season.

14. RUST (*Pucciniastrum minima* Arth.) on *R. ponticum* (Pl. 28, E.)—On young seedlings, this rust appears as a red spotting of the foliage,

Plate 28

A. Bed of *R. ponticum* showing wilt infection.
B. Lophodermium leaf spot on *R. maximum*.
C. Yellow leaf spot on *R. ponticum*.
D. Gall on leaves of *R. maximum*.
E. Rust on young seedling leaf of *R. ponticum*.
F. Basal canker caused by Rhizoctonia on *R. ponticum*.
G. Bud blast on *R. maximum*.
H. & I. Phytophthora blight on *R. catawbiense* hybrid.
J. Wilt infected plant of *R. ponticum*.
K. Leaf scorch of *Azalea hinodegiri*, young infections.
L. *Phyllosticta saccardoi* on *R. maximum*.
M. *Phyllosticta* sp. on *R. maximum*.
N. *Phomopsis* sp. on *R. catawbiense* hybrid.
O. Mosaic on *R. catawbiense* hybrid.
P. Slime mould on *Azalea schlippenbachii*.
Q. Dodder on *R. carolineanum*.

uredosori becoming abundant on the lower surface of the leaves as orange-red pustules. Heavily infected seedlings, if small, may be killed completely, and usually the lower leaves wither and die. Rust infections are often followed by *Pestalotia macrotricha* Kleb. so as to give one the impression that the rust had caused a widespread necrosis. Disease of minor importance usually.

Control: Use dusting sulfur at two-week intervals during July and August if necessary, particularly on seedling stock plants.

15. WESTERN RUST (*Mélampsoropsis piperiana* Arth.) On *R. californicum*.—This rust disease occurs in great abundance on native *Rhododendron californicum* on the western coast, but has not been observed on other species. Numerous small, reddish yellow spore pustules are produced on the lower surface of infected leaves.

Control: Although no work has been done on the control of this rust, the use of dusting sulfurs as above should prove efficacious.

16. YELLOW LEAF SPOT (*Exobasidium vaccinii* (Fcl.) Wor.) on *R. ponticum* and other species and hybrids. (Pl. 28, C.)—On the former species, where it is most severe, very distinct yellow spots are produced on the foliage, at first minute and circular, later enlarging with irregular or scalloped margins and brown centers. Frequently the margins become tinged with red. Sporulation occurs as a fine white meal on the lower surface of these spots. On other species and hybrids in general, a brown necrotic spot occurs without the primary yellow spotting.

Control: Bordeaux mixture 2-2-50 at 10-14 day intervals on *R. ponticum* where control is most needed.

17. GALL (*Exobasidium oxycocci* Rost.) (Pl. 28, D.)—This gall forming species of Exobasidium occurs commonly on *R. maximum* and *R. catawbiense* in their native mountain habitats and on *Azalea* spp. under greenhouse conditions. Typical large white galls are formed on young foliage, sometimes on the petals of opening blooms and seed pods. Galls may involve the entire leaf or inflorescence.

Control: Hand picking young galls in greenhouses. Spraying with 2–2–50 Bordeaux mixture at 10–14 day intervals will also assist in checking infection.

18. PHYLLOSTICTA LEAF SPOTS (*Phyllosticta* spp.) On *Rhododendron* spp. (Pl. 28, L. M.)—There are at least three distinct species of Phyllosticta causing leaf spots on Rhododendron. *Phyllosticta saccardoi* Thum and *P. maxima* E. & E. cause symptoms much alike. Both species cause spots either marginal or terminal on the foliage. The dark brown zonate, necrotic spots often cover half of the leaf. The upper surface is slightly roughened to the touch due to the slightly protruding

beaks of the pycnidia. These pycnidia are usually very abundant in the former species and sparse in the latter. The third species causes a silvery white spot on the foliage of *R. maximum*. The spots are light brown on the under surface of the leaf, are not over 3/8 inch in diameter, and minute black pycnidia occur sparingly in the center of the spot on the upper surface of the leaf. The former two species are of general occurrence and together do considerable damage. The last species is of little economic importance.

Control: Since these spots usually occur only on larger plants of salable sizes in the nursery, fungicides are not usually recommended. If of sufficient severity to warrant fungicidal applications, two applications of Bordeaux mixture, 10 14 days apart immediately after blooming should be recommended.

19. LOPHODERMIUM LEAF SPOT (*Lophodermium rhododendri* Schw.) On *R. maximum* and *R. californicum*. (Pl. 28, B) —This disease causes large silvery white spots with reddish raised margin on the foliage of *Rhododendron maximum* particularly in the southern states and on *R. californicum* on the western coast. Very prominent oval black fruiting bodies appear on the upper surface. The lower surface of infected areas is a light chocolate brown.

This disease is of little economic importance in nurseries.

20. AZALEA LEAF SCORCH* (*Septoria azaleae* Vogl.) On *Azalea hinodegiri*, *A. indica* and its varieties, *A. albicans* and Ghent azaleas. (Pl. 28, K.)—Rather diffuse yellowish areas first appear on foliage, becoming brown in the center as they enlarge, and more definite in outline. Bright or deep reddish margins to the spots are common on some varieties, absent on others. On Madame Petrick and other indica varieties, primary yellowish spots do not always occur, the tissues immediately becoming brown surrounded by a deep reddish border. The leaves fall prematurely thus interfering with the forcing of the plants. Sporulation is abundant on the fallen foliage in pycnidia on either surface of the leaf, but very rare on foliage still on the plants. Very minute pycnidia, occuring in groups can be seen with difficulty without the aid of a lens. *A. hinodegiri* is the most susceptible species, but Madame Petrick variety (indica) is also very susceptible. The disease is most severe under greenhouse conditions, on forcing varieties during the fall and winter.

Control: Bordeaux mixture applied at 10–14 day intervals during the growing season from July 15 until plants are housed.

21. MOSAIC (Virus) (Pl. 28, O.)—Malformation in the shape of leaves of *R. ponticum* and certain hybrid varieties, accompanied by marked

wrinkling or rugosity of the leaves and chlorotic areas, has frequently been observed in nurseries, and has been reported as mosaic from Germany. Attempts to transfer the condition to healthy plants by inarching has failed, and the true nature of this disturbance is still in doubt.

Leaf and Stem Troubles

22. PESTALOTIA LEAF AND STEM SPOTS. (*Pestalotia macrotricha* Kleb. and *P. rhododendri* Guba). (Pl. 27, J)—Both these organisms are weak parasites, gaining entrance to the plant through weakened or injured tissues. The spots on the foliage are silvery-gray on the upper surface, light brown below, and thickly dotted on the upper surface with the black acervuli and spores of the organisms. During wet weather the spores may ooze out in tendrils or as black droplets On stems, the same silvery spots are produced. The former species is the most common fungus found associated with necroses on rhododendron, and follows such injuries as insect feeding or sucking punctures, sunscald, winter injury, and lesions produced by other fungi. *P. macrotricha* also occurs on *Azalea* spp

Control: Prevent winter injury by mulches and wind breaks such as coniferous evergreens or artificial frames Control insects, and provide generous mulches.

23. PHOMOPSIS LEAF SPOT AND CANKER (*Phomopsis* sp.) (Pl. 28, N.) On the foliage of certain hybrid varieties and *Rhododendron maximum*, rather large spots, 10–15 mm. diameter, with a broad definite, reddish brown border, are produced by this organism. These spots are silvery white in the center, zonate, and with numerous pycnidia of the organism concentrically arranged in the center of the spot on the upper surface. This fungus also causes indefinite cankers on older stems, resulting in the death of the infected branches.

Control: Cut out and burn infected branches.

24. PHYTOPHTHORA BLIGHT* (*Phytophthora cactorum* (Leb. & Cohn) Schroet.) (Pl. 27, K., Pl. 28, H.I.)

This widespread fungus found on many hosts causes large water soaked areas on the foliage of hybrid varieties of rhododendron, under conditions of dense shade and high humidities. The infected areas become brown, zonate, silvery white in spots on the upper surface, and light chocolate brown below. On tender new growth dark brown sunken cankers and a general die-back of the branches are produced. Girdling cankers are formed on older tissues killing all the terminal portions of the infected branch. The fungus advances down the stem, often killing the entire plant.

Control: Lessen shade if possible. Prune out all diseased branches and burn. After blooming spray with Bordeaux mixture 2-2-50, making at least two applications 10-14 days apart.

25. BOTRYTIS BLIGHT (*Botrytis* sp.)—Botrytis blight is severe only on seedlings or on plants in the grafting chambers Infected leaves and stems are usually covered with a grayish brown felt composed of spores and conidiophores of the fungus. In grafting chambers, leaves and young stems are rapidly decayed. In seedling frames, sclerotia are produced in the infected leaf tissue. The fungus overwinters as sclerotia in leaf fragments

Control: Rotate frames for growing seedling stock. Bordeaux sprays have been effective in frames if applied at 7-10 day intervals during cloudy or wet weather. Copper-lime dust should prove satisfactory in grafting chambers.

Bud Diseases

26 BUD BLAST (*Sporocybe azaleae* (Pk) Sacc.) On *Azalea* spp. and *Rhododendron* spp. (Pl. 28, G.)—This disease is particularly severe on *R. maximum* in its native habitat in the southern mountain regions. It causes a browning and death of the buds and frequently a slight canker at the base of the bud. The infected buds are covered with minute black bristles, the sporulating tufts of the organism. It has been observed but once in commercial nurseries and is, therefore, of little economic importance except on collected stock from regions where it is known to occur.

Root and Stem Diseases

27. WILT* (*Phytophthora cinnamomi* Rands) On *Rhododendron* spp. (Pl. 28, A. J.)—Wilt is particularly severe on *R. ponticum* and hybrid seedlings. This disease is primarily one of young stock. It occurs frequently on grafted plants, however, two and three years old, but is rare on older plants. It causes a root rot, wilt, and death of seedlings in frames in spots usually. The organism is soil harbored.

Control: Practice rotation of frames for growing stock, adjust soil acidities to pH 4 to 4.5, use light soils with good drainage, and avoid excess of irrigation.

28. DAMPING-OFF AND BASAL CANKER (*Rhizoctonia solani* Kuhn.) (Pl. 28, F.)—The most frequent cause of damping-off of rhododendron seedlings is the common Rhizoctonia. It also causes a canker at the union of scion and stock in grafting chambers, and a basal canker at the soil level on one and two year old *R. ponticum* plants. Such cankers cause

plants to turn yellow, wilt and eventually rot off completely. It also causes the death of branches of older plants of *R. carolineanum* and probably of other species.

Control: Light mist sprays of organic mercuries on seedling flats have given control of damping-off but such sprays should not be applied until after the hypocotyls are free from the seed coat and standing erect.

29. ROOT ROT (*Armillaria mellea* (Vahl.) Sacc.) On *Rhododendron* spp. and *Azalea* spp.

Plants are killed by the attacks of this fungus on the roots, where it causes a wet decay of the cortex and bark, which has a distinct mushroom odor. Black strands of fungous tissue envelop the roots and enter the cortex. White fans of mycelium are usually present under the loosened bark immediately above the soil level.

Control: Increase the vigor of the host by fertilization, and if plants are not too far gone, exposure of the crown to the air for a year has been advised

30. DODDER (*Cuscuta gronovii* Willd.) On *Rhododendron* spp. and *Azalea* spp. (Pl. 28, Q.)—Dodder seeds are brought to the nurseries in muck soils and leaf molds used in preparing the nursery soils for these plants. Young dodder plants twine about their host, attaching themselves by means of haustoria. It is through these haustoria that the dodder derives all its moisture and nutrients. This parasitic flowering plant, very evident in June as long bright orange yellow runners, causes a reddening of the foliage of the attacked plant, due to the loss of nutrients It frequently causes defoliation beyond the point of attachment

Control: Pick out the bright orange yellow runners early in the summer and do not let the plant go to seed.

Non-Parasitic Diseases

31. SLIME MOULD (*Physarum cinereum* (Batsch.) Pers.) (Pl. 28, P.)—This slime mould under conditions of high humidity frequently covers the lower leaves of seedlings with a slime and later a dark purplish gray powdery spore mass. The organism is not strictly parasitic, but if abundant, it causes the death of the seedlings by suffocation. *A. schlippenbachii* seedlings have been observed completely covered with the fruiting structures of this mold and killed thereby.

THE PROTECTION OF FOREST NURSERIES FROM WHITE-PINE BLISTER-RUST INFECTION

By S. B. FRACKER and R. A. SHEALS, *Washington, D. C.*

ABSTRACT

White pine nursery stock can be, and in many cases is being, protected from blister rust by a Ribes-free zone around the premises. Consistent intensive effort is required and the costs range from less than one hundred dollars to a thousand dollars or more for a single nursery. An annual follow-up is necessary. Only five-leafed pines so protected are allowed to be shipped out of infected States except where the shipment is consigned to a point in one of the several northeastern generally infected States.

All white pine nursery stock should be produced under protected conditions, not only to avoid the danger of introducing the blister rust into uninfected localities, but to avoid loss and disappointment on the part of the purchaser.

The gradual spread of the white pine blister rust has made the protection of white pine nursery stock from infection even more important and pressing than in past years owing to the increasing number of nurseries which are becoming exposed to infection. Nursery concerns which produce white pines or other pines which bear needles in bunches of five should by all means take steps toward the protection of the stock at the earliest possible date even though the blister rust is not as yet known in their vicinity or even in the State in which they are located. While the necessary Ribes eradication work will require some time and effort, the increased market authorized under the blister rust quarantine regulations and resulting from the known healthy condition of the trees should make the work well worth its cost for nurseries having any considerable volume of business in the production of conifers.

Quarantine regulations issued for the purpose of retarding the spread of the white pine blister rust into uninfected localities prior to 1928 primarily involved embargoes on the shipment of five-leafed pines from infected to noninfected regions or from generally to lightly infected areas. Under these embargoes no interstate movement of five-leafed pines into protected areas was allowed under any conditions.

By 1928, investigational work and large-scale field experience in the protection of forested areas against blister rust infection by Ribes eradication had reached such a stage that it seemed possible to undertake the protection of nursery plantings of five-leafed pine in a similar manner. A revision of the Federal blister rust quarantine regulations was issued during the summer of that year, effective August 15, 1928, making provision for this new plan. It authorized the interstate movement under permit of five-leafed pines from the generally infected areas, con-

sisting of the New England States and New York, into the lightly infected States east of the Great Plains regions and also from Washington into Oregon and Idaho when they had been raised from seed in a nursery free from Ribes plants and with a Ribes-free zone around the premises. The change was based on the proven effectiveness of a Ribes-free zone as a permanent protection to five-leafed pine stands.

PRESENT AND PAST REQUIREMENTS AS TO MOVEMENT.—The specifications prescribed for the protection to be given approved five-leafed pine nursery stock are given in regulation 2 of Federal quarantine No. 63. They have remained substantially unchanged since 1928 and are as follows:

> Such pines shall be grown from seed in a location within 1 mile of which there have existed since the time of planting said seed no European black-currant plants and within 1,500 feet of which there have existed since the time of planting said seed no currant or gooseberry plants of any size or variety which in the judgment of the inspector would involve risk of spread of the white-pine blister rust.

These restrictions are more stringent than are the control measures which are applied to forest lands, a 1500-foot Ribes-free zone being required around nursery premises, while a 900-foot zone is sufficient for forest protection. This difference is due to the fact that the sporidia from Ribes (other than *R. nigrum*) may be carried more than 900 feet by the wind but that they usually do not remain viable beyond that distance in sufficient numbers to cause significant damage in commercial pine stands. In the case of nursery stock, as nearly as possible an approach to absolute protection is attempted.

A revision of the blister rust quarantine regulations, effective January 1, 1933, further recognizes the practicability of protection of five-leafed pines in nurseries located in the infected States by authorizing nation wide movement in cases where the stock is found to have been grown from seed in Ribes-free areas. In this revision five additional States—Iowa, Ohio, Maryland, Virginia, and West Virginia—and the District of Columbia, are classed as infected.

The Mississippi Valley line has been eliminated as a line past which shipments of five-leafed pines may not be moved from east to west, and it will be noted that five-leafed pines may hereafter be consigned from non-infected States to any part of the country under the State Nursery Inspection Certificate issued by the State from which the shipment is shipped.

Another important change in the present regulations is that the destinations to which pines are allowed to move under Federal permit

may be limited. The extent of such limitation will depend primarily on the status of the nursery involved with respect to known infestation of blister rust in that part of the country and the local condition in and around the nursery with respect to freedom from Ribes.

A Ribes-free zone greater than 1500 feet in width may be required when necessary in the department's judgment to ensure freedom from infection This additional safeguard is expected to be required in cases where there are concentrations of Ribes very close to the 1500-foot boundary, or where there are mountains, ledges or exposed areas on which Ribes are growing near such boundary

Experience in the administration of this work and in the inspection of the environs of the nurseries during the past 3½ years has resulted in the development of a considerable body of information concerning the practicability and effectiveness of nursery protection by this means.

PROCEDURE.—The present plan of procedure is that upon receipt of an application from a nursery, the application is referred to the Bureau of Plant Industry for any information they may have concerning Ribes conditions in the environs of the nursery or the extent to which Ribes eradication may have been carried out in the vicinity in connection with the general prosecution of cooperative blister rust control work. This work is conducted jointly by the Bureau of Plant Industry and the affected States In a number of cases this request results in information coming from the Bureau which shows definitely that the Ribes have not been eradicated in the vicinity of the nursery In such cases no inspection by the Bureau of Plant Quarantine is made at that time but the nurseryman is advised to consult with the Bureau of Plant Industry and with the State nursery inspector as to the methods and cost of Ribes eradication and the possibility of making arrangements for securing trained supervision and assistance in the work in cooperation with Federal and State authorities.

After careful Ribes eradication has been carried out in the vicinity of the nursery, freedom from Ribes is checked by a competent, experienced quarantine inspector and a general study and report of the situation are made. If the nursery and its surroundings are found to be disease-free and Ribes-free to the extent required by the regulations, permit for the interstate shipment of five-leafed pines either to lightly infected States, to all States except the Pacific Southwest, or throughout the United States is issued. If a careful job of Ribes eradication has been accomplished and no sprouts or seedlings are found except a limited number which can be and are pulled up in the early spring before sporidia can be distributed, a permit is likewise issued to the owner.

In a considerable number of instances, however, inspectors have reported that, in spite of rigorous efforts at Ribes eradication, Ribes plants are proving so persistent that no permit can be issued for the season concerned These cases may be divided into two classes. In one class the nurseries are located in such a situation, e. g., near swamps, that there appears to be no probability that a complete and satisfactory job of Ribes eradication can be accomplished within a reasonable number of years. This condition has been due in some cases to beds of skunk currant with very persistent root stocks which experience has shown are difficult to eliminate. In other cases, particularly in the Pacific Northwest, certain native species of Ribes plants grow under stream-type conditions which are difficult to control to the extent necessary for nursery protection.

The second class of nurseries to which it has been necessary to refuse permits is that in which Ribes eradication efforts will need to be extended through one or more additional seasons before the work can be completed. In one instance this was due to Ribes sprouts and seedlings coming up under a dense mat of Potentilla where it would be necessary to eliminate the Potentilla before Ribes eradication could be completed. In another instance this was due to the presence of such heavy stands of poison oak among the Ribes as to decrease crew efficiency through the workers' knowledge of the virulence of the poison oak In another case a deep swamp with standing water showed Ribes growing on small low islands.

One of the features of the plan of operation has consisted in requiring that application be filed with this Bureau before the pine seeds were planted. This requirement is made in an attempt to avoid disappointment on the part of nurserymen who might plant seed with the expectation of having a market outside the infected regions and then find that Ribes eradication in the vicinity was too expensive or diffiicult to be practicable. The Department after finding that Ribes eradication has been carried out satisfactorily around a plot on which the nurseryman expects to plant pine seeds, tentatively approves the plot subject to reinspection before the resulting pine seedlings are shipped.

Even after tentative permit has been issued and the pines are growing on the premises, the persistence of sprouts and seedlings in the vicinity has involved something of a problem. In one case it has in fact been necessary to refuse a permit on this basis after one had been issued during the previous year for the same tract. It is necessary for the nursery to arrange for crew coverage of the environs of the premises each spring to be sure of the elimination of sprouts and seedlings before there is any possibility of the development and distribution of sporidia.

COSTS.—With regard to costs, it will be recalled that the average cost of commercial protection of forest stands ranges from 20c or less per acre to several dollars per acre in the eastern States and may run into considerable sums in stream-type eradication in the Rocky Mountains and Pacific Coast areas In protecting *forest* stands, active crew eradication effort may be necessary over a much smaller area than is covered by the pine itself and satisfactory control is accomplished by keeping the Ribes factor below 50 or 100 feet of live stem per acre. In the protection of a *nursery*, however, it is necessary not only to cover the area on which the pine stock is raised but also the 1500-foot border and to do the work very intensively so as practically to eliminate all live stem entirely. This greatly multiplies the acreage to be covered and the cost A 1500-foot border around a 25-acre plot occupies over 300 acres in addition to the area of the plot itself. The exact acreage depends on the shape of the plot. In the case of nurseries growing five-leafed pines strictly for reforestation purposes, the 25-acre plot used as an illustration may be large enough to provide for crop rotation and other nursery management practices If the pines are being grown by wholesale nurseries on a considerable scale, some of their output will probably be intended for ornamental use and it is then necessary for the nursery to provide space not only for its seedling plantings but also to spread the young trees out over a very much larger area than the seedling plot, after they are two or three years old. In such cases, a total protected area of 25 acres may not be sufficient and each acre added to the protected plot makes it necessary for the Ribes eradication crew to cover 3 or 4 additional acres in the environs.

Under ordinary conditions a nurseryman needs to undertake Ribes eradication therefore with the definite expectation of spending several hundred dollars to accomplish it and this amount may run into $1,000 or more in the event that any particularly difficult situation—such as swamps, streams, or rocky cliffs are involved. Casual attempts to eliminate Ribes without consistent and supervised crew work have invariably resulted in disappointment.

EXPERIENCE SINCE 1928.—During the fiscal year 1929, applications were received from nine New York and New England nurseries for certification under these provisions. In five instances wild or cultivated currant and gooseberry plants were found within 1500 feet of the nursery premises and it was necessary to withhold certification of the premises concerned. In an additional pine-growing nursery, blister rust was found on the premises, and in still another instance, while no Ribes were found within the 1500-foot zone, there was evidence of such Ribes having

been present in the past since the pine seed had been planted. Certification was necessarily also refused in both the latter two cases. The two remaining nurseries from which applications were received were issued permits during the summer of 1929, one in Maine and one in Vermont.

In the spring of 1930, a third permit was issued under these provisions, this one to a nursery in New York In addition, a tract in Connecticut on which a nursery has since planted five-leafed pines was tentatively approved for that purpose.

During the spring of 1931 applications were received from seven nurseries in the New England States and one in New York, and inspections of their premises were made in May and June The premises of five out of the eight were found to be maintained in compliance with the requirements although only four permits were issued, as one of the nurseries had transplanted pines in such a way that they had been exposed to infection. Three of the four permits covered plots in which the pine was still too young for sale

In the meantime, four nurseries in the Pacific Northwest have engaged in similar Ribes eradication. Two of them have discontinued their efforts, apparently because of difficulties involved in establishing a Ribes-free protective zone Of the remaining two nurseries, one, in Montana has not yet submitted an application for a pine-shipping permit. The other, located in Idaho, has been issued a permit authorizing shipment into the infected States.

During recent months permits have been or are being issued, in the eastern United States, to one nursery in New York, two in Iowa, one in West Virginia, and two in Maryland The permits to the nurseries in Iowa, West Virginia and Maryland are issued under the authorization given in the last sentence of paragraph 4 (a) of Section B, Regulation 2 of the white pine blister rust quarantine, as revised effective January 1, 1933, which reads as follows: "The requirement that the Ribes-free conditions described must have been maintained since the time of planting the seed may be waived pending the completion of Ribes eradication in the environs of the nursery, in the case of premises which, on account of their great distances from known points of blister-rust infection and the relative scarcity of susceptible Ribes in the vicinity of the five-leafed pine stock, represent in the judgment of the Bureau of Plant Quarantine little or no risk of being involved in blister rust infection".

None of these permits now outstanding, however, authorize distribution throughout the entire United States. All of them specify the States into which shipments may be made, in some cases limiting distribution to the infected States, and in others authorizing shipment throughout

the United States except into the southwestern limber pine and sugar pine area.

RESULTS.—Thus far no blister rust has been found on any five-leafed pine nursery stock grown under the protected conditions specified in the quarantine regulations. The results from that standpoint are most gratifying. It is necessary to interpret this fact in connection with the unsatisfactory record of nurseries located in generally infected areas where Ribes eradication has not been carried out satisfactorily in the vicinity. These nurseries are in many cases examined by the State nursery inspectors, and State nursery inspection certificates have been issued In several instances the inspectors (or the nurserymen) have culled out visibly infected pines and the rest have been certified as apparently free from disease In view of the fact that the blister rust cannot normally be seen on the infected pine until from twelve months to several years after the infection takes place, this practice has resulted in the shipment and transplanting of infected trees. In one instance of this kind in which an interstate shipment resulted in the planting of white pine at a considerable number of locations after redistribution in the State of destination, it was discovered two years later that many of the trees were infected with blister rust, and this case has resulted in protests against the shipment of five-leafed pines which have not been given adequate blister rust protection.

SUMMARY AND COMMENTS--Experience since 1928 indicates that the protection of five-leafed pines in nurseries located in blister rust infected areas is practicable

The method consists in the elimination of all Ribes for 1500 feet or more around the nursery and the destruction of *Ribes nigrum* for a distance of one mile.

The area which must be covered in the 1500-foot zone varies from 300 acres upward depending on the size of the nursery plots.

The one-mile zone from which *Ribes nigrum* must be eliminated occupies an area of approximately 3½ square miles.

The cost of the protection of a nursery can be expected to vary from less than one hundred dollars to one thousand or more depending on the nature of the nursery's environs.

Persistent eradication work repeated for a number of years has proven to be necessary.

The department has not refused permits where the only Ribes found were a limited number of sprouts and seedlings discovered and destroyed in the early spring. Nevertheless less than one-half of the New England and New York nurseries which have engaged in Ribes eradication work

around their premises, have as yet been able to reach the standard needed for protection.

Five-leafed pines grown in nurseries in generally infected areas without satisfactory rust protection by means of Ribes eradication, are likely to and, in many cases, do carry at least a small percentage of infection. Roguing of visibly diseased trees does not constitute protection against such carriage of infection by the nursery stock concerned.

A very small degree of infection, such as less than 1%, is, in an economic sense, probably unimportant in the case of commercial plantings of pines located in territory generally infected with the blister rust. Pines planted in such an area, regardless of source or freedom from disease when planted, should be permanently protected against blister rust infection by Ribes eradication or they are likely not to reach maturity.

Five-leafed pines grown in infected sections of the United States should not be planted in noninfected areas (especially in States in which five-leafed pine stands are of commercial importance) unless the nursery stock has been grown from seed under the standard rust-protection conditions outlined.

Is the Absorption of Copper by Certain Crop Plants Influenced by Climatic, Soil, or Other Factors? In connection with the use of Bordeaux mixture (4–4–50) as a spray for the control of *Empoasca fabae* (Harris) on peanuts, it was desired to learn whether this host plant absorbed copper through the foliage (thereby killing the leafhoppers as an insecticide) as DeLong, Reid, and Darley reported for beans and potatoes in Ohio. (See Jour. Econ. Ent. 23:383–394.) The first tests were made at Arlington Experiment Farm (P. O., Rosslyn, Va.) September 6, 1932, on the juices extracted from 100 grams of green leaves of sprayed and unsprayed peanuts. The hydrogen sulphide and potassium ferrocyanide tests were both used and three series of these tests for copper gave only negative results. Further sprayings with Bordeaux mixture were then made September 15 on peanuts, potatoes, and beans, which crops were all in a good growing condition. A total of nine series of tests on the sprayed and the unsprayed plant material yielded only negative results. The xanthate method, applied qualitatively (see Jour. Ind. Eng. Chem. Anal. Ed. 3:314, 1931), was next used on each of two ashed samples (50 grams green weight) of both peanuts and potatoes, sprayed and unsprayed. No significant differences in the amount of copper in the four samples from each kind of plant were found. The results of these preliminary tests are presented to direct attention to the fact that, under certain conditions of climate and soil, copper from Bordeaux mixture may not be absorbed by the plant

F. W. Poos, *Division of Cereal and Forage Insects, Bureau of Entomology,*
R. B. Deemer, *Division of Soil Fertility, Bureau of Chemistry and Soils,*
U. S. Department of Agriculture

STATUS OF POTATO WART IN 1932

By R. H. Bell, *Harrisburg, Pa.*

ABSTRACT

Potato wart was introduced into the United States presumably from Europe about 1912 but was not discovered until 1918. To date infection has been found in three states, Pennsylvania, Maryland and West Virginia. Introduction seems to have resulted from potatoes imported and distributed through company stores to various mining districts where many gardens but few farms are known to harbor the disease. Control has been through enforcement of a quarantine which permits planting of immune varieties only and prohibits movement of potatoes and various other carriers out of the restricted areas. Very few additional infections have been found since the original survey, indicating that the quarantine has been effective. Investigations by the Pennsylvania Department of Agriculture have revealed that: (1) Infection persists in the soil after a lapse of thirteen years in potato growing; (2) Thorough cultivation for six years tends to reduce but has not eliminated wart; (3) Very little, if any, wart develops above seventy degrees F. soil temperature; and (4) Certain new soil sterilizing materials look promising for use in connection with administration of the wart quarantine.

It has not been definitely established just when or exactly how potato wart was introduced into this country but it is apparent that it must have occurred several years prior to its discovery near Hazleton, Pennsylvania, in 1918; that is, either before or soon after establishment of foreign restrictions provided for in the Federal Act of 1912. All indications point strongly to the rather heavy importations of potatoes during the short crop year of 1912. At least it is true that considerable quantities of potatoes were imported at that time from infected areas of Europe and distributed through company stores in various sections where wart was later discovered.

Fortunately a large majority of areas affected are distinctly isolated, both physically and as to the normal movement of the potato crop. At least this continues to be the case in Pennsylvania which contains the bulk of the territory affected. The fact that there is practically no outward movement of commodities likely to carry wart greatly favors the maintenance and effectiveness of restrictive measures, and eases the burden on those who must comply with local restrictions.

Another fortunate feature is that the original survey conducted by the federal department and states cooperating functioned practically one hundred per cent in locating infected areas. Where the natural handicaps are taken into account, as well as the fact that only the status of areas planted to susceptible varieties at that time could be determined, it is nothing short of remarkable that the determination of the extent of infection could be made so complete.

The main feature of wart control work in Pennsylvania, and I believe in Maryland and West Virginia as well, has been the maintenance of a quarantine. At the beginning there was some support for complete prohibition of potato culture in the restricted areas but finally the use of immune varieties was adopted as a policy throughout the general area with outward movement of the crop prohibited. Within the past two years Pennsylvania has permitted planting of any variety in certain locally isolated areas within our main quarantine district in which wart had not been found Such plantings, however, are made under special permit and receive special inspection, both during the growing season and at digging time, and potatoes so grown may not be moved out of the restricted area. So far wart has not been found in these special areas notwithstanding they were exposed to infection from nearby areas from 1918 to 1930. Here again the situation is likely favored by the fact that we are dealing with isolated mining communities where potatoes are grown in small patches and gardens and there is practically no surplus for market or even sale to neighbors

This growing of susceptibles under control in sections likely to have been originally infected, or through exposure to have since become infected, should contribute to our knowledge of the natural dispersal of wart when unrestricted In fact, had such a policy been adopted at the beginning, we should have known very definitely by this time the exact extent and location of infection throughout the regulated areas Such information would be very valuable if the time ever comes when we can proceed with a program of soil treatment or other means of cleaning up infected districts. Consequently, in the case of a small additional infection recently discovered in Pennsylvania, it is planned to require the use of immunes only in the two or three gardens known to harbor disease. Other varieties may be planted elsewhere within the area but only under permit, with field and digging inspection and outward movement prohibited In this way we hope to locate all infections within the area and if investigations under way prove it practicable, to clean them up as found

It is perhaps true that among plant quarantines now or formerly in effect, the potato wart quarantine stands out as one of the most effective in preventing the spread of the pest concerned. Notwithstanding Pennsylvania has done extensive scouting outside the quarantine districts during the past thirteen years, giving special attention to suspected areas, only four small spots have been found in addition to those located by the original survey Three of these were near infected territory and all show unmistakable evidence of dating back to the original infection.

INVESTIGATIONAL WORK.—Ever since the discovery of potato wart in Pennsylvania, attention has been given by both state and federal agencies to a study of the technical aspects of the wart situation as a necessary adjunct to proper quarantine procedure. A well equipped laboratory, provided by the Pennsylvania Department of Agriculture, is located at Hazelton and field plots with additional laboratory facilities are in operation near by. A series of automatically controlled temperature tanks constitute an interesting and essential part of this equipment. Mr. R. E. Hartman, who has been identified with the wart work in Pennsylvania since the beginning, is in charge of these investigations as well as the field administration of the quarantine

The present program includes, among other things, studies of the longevity of wart in the soil, effect of soil temperatures and moisture; effect of various cultural practices; additional host plants and trial of various chemicals as soil sterilizing agents. Most of these, or perhaps all, have been subjects of previous investigation but without substantial results from the standpoint of the quarantine or control.

When the quarantine was established in 1919, our state was hopeful that wart could be starved out in ten years. However, we had wart develop this year in gardens where no potatoes of any kind had grown since 1919 This experience has been repeated annually during the past thirteen years.

Clean and frequent cultivation was at one time announced as an effective control. Our experience indicates that cultivation does reduce wart, but will not eliminate it even when practiced over a period of six years. Thorough aeration is more effective but not practical

We find that soil temperature is a vital factor Seventy degrees Fahrenheit soil temperature appears to be the upper limit for wart development unless there is excess moisture present in which case we have had some development up to about seventy-two degrees Fahrenheit. This may have some bearing on the fact that wart is found in this country only in high mountain areas where soil temperatures are appreciably lower than in comparatively nearby valley areas Field studies covering the period of April 15 to November 15, 1931, showed average soil temperature at Harrisburg to be seven to ten degrees Fahrenheit higher than at Hazelton and Ebensburg—the latter two in the elevated wart area—and well above seventy degrees Fahrenheit, the limit of wart development. We have observed, also, a marked falling-off of wart development in experimental plots the last three seasons due, no doubt, to the abnormal heat and lack of rainfall.

Soil sterilization has been studied for years and various effective materials have been demonstrated, but either excessive cost or detrimental effect on plant growth has prevented their adoption as a means of avoiding or eliminating the quarantine. During the past year we have hit upon a material which to date appears quite promising and the cost would not be beyond reason for quarantine purposes. Should this work out, we propose to treat infected gardens in small outlying areas, throw these areas open to planting of other varieties under permit but otherwise continue the quarantine with inspection of the growing crop and at digging time. If no other infections show up over a period of a few years, the quarantine would be lifted in these areas and we would proceed to treat other areas in the same manner.

Some such policy appears to be the only alternative for Pennsylvania unless some one develops or discovers an immune variety superior to our present Rurals and succeeds in having it adopted throughout the state. Even then, there would doubtless be sufficient susceptibles grown to keep potato wart a live issue with many of our growers.

Parasites of the Sunflower Weevil, *Desmoris fulvus* **Lec., During 1931 and 1932.** During the 1931 and 1932 seasons examinations of sunflower seed to determine the infestation by the sunflower weevil *Desmoris fulvus* Lec., were carried on in Illinois. Records of parasitism are interesting if not of particular economic importance.

Parasites were found in 8 of the 11 lots of seed examined in 1931. Eleven specimens were reared. Of these 10 were *Microbracon mellitor* Say., and one was *Eupelmus cyaniceps* var. *amicus* Girault.

In the 1932 crop 2 out of 4 lots were found to contain parasites. The 2 not parasitized were obtained from a section where sunflowers have not been grown commercially. Nineteen parasites were reared from the 1932 crop, of which 18 were *Microbracon mellitor* Say., and one was a recently identified chalcid, *Trimeromicrus maculatus* Gahan.

The 2 species, *Eupelmus cyaniceps* var. *amicus* Girault and *Trimeromicrus maculatus* Gahan had not been previously reported as parasites of *Desmoris fulvus* Lec. Determinations were made by A. B. Gahan and H. H. Ross.

Since 1928 there have been 80 specimens of parasites of *D. fulvus* reared. Of these, 75 were found to be the *M. mellitor*. The greatest rate of parasitism, however, has been found as 6.2% in 1929. The economic value of the parasite is questionable.

J. H. BIGGER, *Entomologist State Natural History Survey 1114 S. Main St., Jacksonville, Ill.*

THE STEM RUST CONTROL PROGRAM

By F. C. MEIER, *Principal Pathologist in Charge, Division of Barberry Eradication, Bureau of Plant Industry, Washington, D. C.*

Dread of a stem-rust epidemic, the sword of Damocles which hung over the head of the grain farmer in the upper Mississippi Valley during the agricultural development of much of that country is perhaps remembered within the personal experience of some of those present. Lodged and broken straw, heads of wheat filled with shriveled lightweight grain, much of which went out of the thresher through the blower with chaff and straw, were well known to those who experienced rust epidemics. In the early 1900's low yields from fields laid waste with rust, and price discounts on such poor quality grain as was harvested were not unusual, and in some cases finally meant the breaking up of homes and loss of land won by great hardship.

The story is well known, how, after we had lost some 200,000,000 bushels of grain in the United States due to rust during 1916, the farmers of North Dakota, following an example already set by their fellow grain growers in Germany, Denmark, France, and England, began a State campaign against the common barberry This plant was known to be an intermediate host for stem rust, a host plant necessary to perpetuate the disease in northern climates and one on which the causal fungus multiplied abundantly in the spring Among those present today there are men who in 1918 participated in organization of the Barberry Eradidication Campaign in the 13 North-Central States, Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming.

The magnitude of the task ahead was at that time not fully appreciated. Although the harmful common barberry is not native to the United States, it was popular with the early settlers who brought it from Europe It was carried along with the movement of population westward. Barberries were carefully moved, in the covered wagons, from the eastern homes with other prized possessions Later nursery salesmen gave away plants of this easily propagated shrub as inducements for purchase of orchard trees, as payment for a night's lodging, and as other good will offerings. The bright red berries borne by these bushes were attractive to birds which carried the seeds to out of the way places where new clumps of bushes were started. These were soon producing more seeds for spread by birds and other natural agencies. At the time the work of eradication began in 1918 no one knew the extent to which the shrub had escaped cultivation.

In spite of the many handicaps to the work in its early stages, hostility on the part of land owners and city dwellers not acquainted with the role played by the barberry in the spread of rust, the tremendous areas of escaped and fruiting bushes, the fact that exact location of

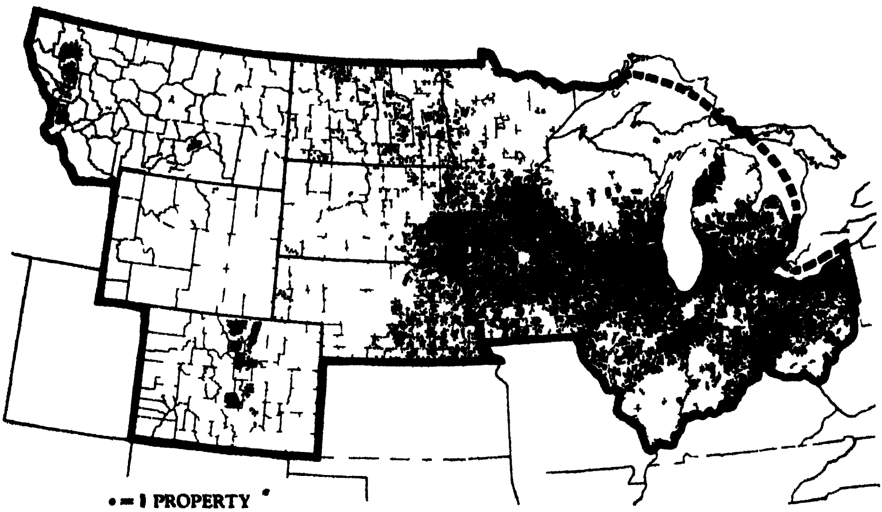

Fig 48 —Rural properties on which barberry bushes were found all surveys barberry eradication 1918 1931

these areas are often unknown, and other difficulties excellent progress has been made

In the 14 years during which this campaign has been under way, approximately eighteen and one-half million rust susceptible bushes have been destroyed in the 13 North-Central and Western grain-growing States comprising the barberry eradication area (Fig 48) That the eradication of these bushes has been accomplished by a decided decrease in rust losses is indicated by the following table

Losses from Stem Rust Decrease as Progress is Made in Barberry Eradication

Wheat Losses Resulting from Black Stem Rust in 13 Northern States by 5-Year Periods		Rust-Spreading Barberry Bushes Destroyed Since Beginning of Stem Rust Control Program	
1916–20	285,000 000 bu	1916–20	4 000,000 bushes
Average annual loss	57,000 000 bu		
1921–25	85,000 000 bu	1916–25	12,000,000 bushes
Average annual loss	17,000,000 bu		
1926–30	45,000,000 bu	1916–30	18,000,000 bushes
Average annual loss	9,000,000 bu		

The eradication of the remaining barberry bushes should further reduce the severity, if not eliminate destructive epidemics of stem rust in the upper Mississippi River Valley. Furthermore, it will retard hybridization of physiologic forms of stem rust which takes place on the barberry leaves resulting in new forms of the fungus capable of attacking varieties of small grain that have previously proven resistant. As a result of past work, the remaining common barberry bushes are few and scattered in some States, while in others, such as Iowa, Wisconsin, Ohio, Illinois, and Michigan, there are many localities in which thousands remain

The losses that continue to occur can be attributed to two causes: (1) The spread of rust from remaining barberry bushes, and (2) The development of rust in certain years as a result of spores carried by the wind from the Southern States where the red or repeating stage of the disease lives over the winter Epidemiology studies made since the beginning of the barberry eradication campaign in 1918 have shown that in the Northern States the early development of stem rust and the most damaging epidemics of the disease are associated with the remaining common barberry bushes However, during certain seasons when an abundance of rust is present in the South and wind, moisture, and temperature conditions favor the northward movement of spores, stem rust may develop in the spring-wheat area as a result of wind-blown inoculum Rust from this source usually appears late in the growing season and is characterized by a scattered distribution over extensive areas Unless crops are abnormally slow maturing, serious rust damage ordinarily does not occur

The Division of Barberry Eradication and cooperating agencies are concentrating on attempts (1) to reduce the expense of finding the remaining barberries in those areas in which they are somewhat scattered, and (2) to reduce the cost of eradication in areas in which the bushes are numerous, particularly where they have escaped from cultivation. Progress is being made in developing the initiative of property owners and children with the result that more individuals each year become interested in stem rust control, learn to recognize the common barberry, and realize the necessity for eradicating it

COOPERATION BRINGS SUCCESS IN THIS PROJECT.—The present degree of success in the enterprise has been possible only as a result of whole-hearted cooperation by all parties concerned.

From the beginning, State Departments of Agriculture in all 13 of the States have been active in work of developing plans for the campaign. State Legislative assistance was prompt. The essential part played by State enforcement agents is well known to those present.

Practical assistance from State Legislatures in the form of direct cash appropriations to supplement Federal funds is part of the program. In one year or another since 1918, all of the important grain-growing States in the area have made substantial appropriations. At the close of the fiscal year 1932, Michigan had made appropriations 12 years out of 14 Wisconsin had made cash appropriations every year In total amount in these 14 years, Michigan led with $58,400 while Minnesota was a close second with a total of $56,500. From North Dakota, the total for 14 years was $40,000 These direct contributions of cash from State Legislatures have been materially supplemented by contributions from millers, grain dealers, railroads, and other commercial agencies who have maintained the Conference for the Prevention of Grain Rust with an office in Minneapolis, now so ably managed by Mr Donald G. Fletcher, Executive Secretary of that organization In the first 14 years the Conference contributed $262,000 in cash

Outstanding among State organizations that have given continuous support to the program are the Greater North Dakota Association and the North Dakota Retail Merchants Association With wheat contributing a large share of the State's income and stem rust one of the chief causes of crop failure, these organizations were quick to take advantage of the opportunity to help rid the State of the rust-spreading barberries.

To the cash contributions from the States and the Conference must be added indirect aid in the form of office space, in some cases automobiles, and services of State employees All States have contributed in this way Total contributions in cash and services from State and other agencies for 14 years have amounted to $1,101,887. During this period total appropriations of the Federal Government have amounted to $4,449,775. The total of all money spent for barberry eradication to date is less than 1/10 of the average annual loss from stem rust during the 5-year period 1916–1920.

Cooperation of nurserymen is essential to the success of the program. It would of course be futile to spend large sums of money for eradicating barberries and leave the door open for others to come in. From the beginning of the work nurserymen have taken a sympathetic attitude. Quarantine inspection under Quarantine 38 (Revised) is giving increased personal contact with the larger nurseries, and as nurserymen find the Department representatives helpful in the matter of identifying barberry species, and suggesting uses for the less well known resistant plants, they are making every effort to aid in the program.

State officials have from the beginning understood the desirability of giving service to nurserymen. An example of this was the request received last spring from Mr. C. W. Ellenwood, Chief of the Bureau of Plant Industry of Ohio for a paper on uses of non-rust susceptible varieties of barberry which might be distributed to the Ohio State Nurserymen's Association. This paper, prepared by our Mr. B. Y. Morrison, who for a number of years has studied the barberries from a horticultural viewpoint was well received. There are many opportunities for such service to nurserymen in the course of our program for securing their aid in preventing the distribution of rust susceptible barberries.

Likewise cooperation of the public schools, 4-H Clubs, Future Farmers of America, the Boy Scouts, and other organizations of young people is important. By work with these groups we are enabled to find unknown locations of barberries with much less expense than formerly when it was necessary to systematically scout all areas. Now to an increasing degree, we are led to locations of bushes by reports from school children. As a natural result of the spread of information concerning stem rust, it is rarely the case that instances of opposition to barberry eradication are encountered. Instead there is an increasing interest on the part of adult farmers which leads to their taking part in the work of eradication.

It is by cooperation of the Extension Service in the 13 States that we have had assistance from the county agents in making local contacts and developing local plans of work. During the past two seasons when more labor has been employed locally for eradication effort, these joint representatives of the Department of Agriculture, the States, and the counties have been especially helpful.

Specific instances of cooperation of organizations and individuals are too numerous to be mentioned in the time available. Many agencies other than those mentioned have lent their support to the project.

THE DIVISION OF BARBERRY ERADICATION. - So much for some of the cooperative features of the work Within the Department of Agriculture this project, originally organized by representatives of the Office of Cereal Investigations, is now administered as a separate Division. In spite of the large area covered, the plan of organization is simple, involving a minimum of overhead expense. No regional offices are maintained. Instead the Washington office deals directly with ten field offices located in or near State College or University buildings.

Summing up activities of the Division they are in brief: (1) Research to provide a sound basis for procedure by determining the factors influencing the occurrence and spread of the stem rust fungus, to improve methods of eradication, and to classify species and varieties of the bar-

berry according to their degree of susceptibility to rust; (2) Informational work intended to instruct grain growers and other property owners in the application of practical measures for reducing the stem rust hazard in the production of crops; (3) Service in eradication of barberry bushes in locations where they are numerous or where stem rust recurs year after year to a damaging extent. It is in the phase of research dealing with classification of barberries, susceptibility tests, and nursery contacts that many of those present today are particularly interested.

SERVICE TO NURSERYMEN.—In the administration of Quarantine 38 (Revised) there are now on the list of barberries which are immune or sufficiently so to warrant their distribution in the wheat-growing States 29 species, varieties, and hybrids Best known of these is the popular Japanese barberry (*Berberis thunbergii*). Among the rust resistant evergreen plants are *B. repens*, *B. aquifolium*, *B. darwinii*, *B triacanthophora*, *B. verruculosa*, and *B. sargentiana*. Study of the plants which may safely be distributed without risk to grain growing regions, convinces one that the restrictions of Quarantine 38 (Revised) need entail no hardship on nurserymen because there are a number of very desirable species known to be entirely immune from or highly resistant to black stem rust.

Inspection activities under supervision of the Bureau of Plant Quarantine bring to light the fact that many nurserymen do not yet understand the quarantine. Many of these men are anxious to know which barberries they may grow. Extension of inspected and approved nurseries will encourage more nurseries to join the list of those growing immune plants only The certified nurseries are at an increasing advantage. In 1931, thirty-one nurseries were inspected in eleven States. Twenty-three were approved after destruction of any susceptible plants found by the inspector on the premises.

DEFINITE PROGRESS MADE IN RUST CONTROL STABILIZES PRODUCTION—In closing it is desired to emphasize the fact that decided progress has been made in removing barberries from the 13 States of the eradication area and in laying a ground work to prevent their return. As progress has been made in eradication, stem rust losses have decreased. This progress was made possible by continuous effort on the part of States concerned, farmers organizations, business men, and individuals who have continuously cooperated with the United States Department of Agriculture. Within this group there are State representatives who have taken an active part in the program.

I was very much interested in a statement made to me recently by an

agricultural statistician of the Department to the effect that from the Crop Reporting Board's standpoint the precision of probable wheat production in North Dakota on July 1 is very much increased because excessive shifts in the probable yield per acre, due to the degree of rust damage, have been eliminated. This statement is more or less suggestive of what has occurred in several of the Western States where barberry bushes are now few and scattered.

CONTINUED COOPERATION ESSENTIAL.—The very fact that stem rust epidemics have become fewer and less severe during the past several years may tend to slow up the work. There is always the danger of a tendency to slacken control efforts when immediate danger of destructive epidemics seem to have passed. Remembering that while only scattered bushes remain in certain States, in others extensive areas of escaped seeding bushes are still to be found, it is clear that a steady drive must be made to gain barberry-free territory and to prevent reinfestation of land from which bushes have been removed.

The effectiveness with which this may be done will depend on continued effort of the Federal and State Governments in locating and destroying remaining bushes, increased cooperation of schools and other informational agencies, the State support given the project in the form of cash appropriations and the continued organized effort of State Crop Disease Control agencies. Past achievements give confidence that this most extensive of all plant disease control projects yet undertaken is coming through to success not only as a rust control measure but as an outstanding example of cooperative effort

PROGRESS IN PHONY PEACH DISEASE ERADICATION

By WILLIAM F. TURNER, *Agent, Phony Peach Eradication, Bureau of Plant Industry, U. S Department of Agriculture*

ABSTRACT

The phony peach disease is an infectious systemic disease for which no cure of the diseased tree is known. It is now known to occur in twelve Southern States and in Illinois. It is generally present and severe in Georgia and South Alabama; during the last few years more than a million trees have been either pulled or abandoned and many growers have been forced out of production. Individual cases are widely scattered throughout all of the other Gulf States but its results in these areas are not yet commercially destructive; very few infections have been found in the remaining states, namely Oklahoma, Arkansas, Missouri, Tennessee, South Carolina, North Carolina, and Illinois. An eradication campaign was begun, in 1929, by the Federal Department of Agriculture, in cooperation with the State of Georgia, which at that time was the only state in which the phony disease had been recognized. This work has been continued and extended to all areas now known to be infected.

Confronted with the problem of controlling a disease that threatened the very existence of the entire peach industry of the United States, having already taken such heavy toll in the most concentrated peach district in the East that over a million trees had been pulled up in three years and many growers had been forced out of the industry; a systemic

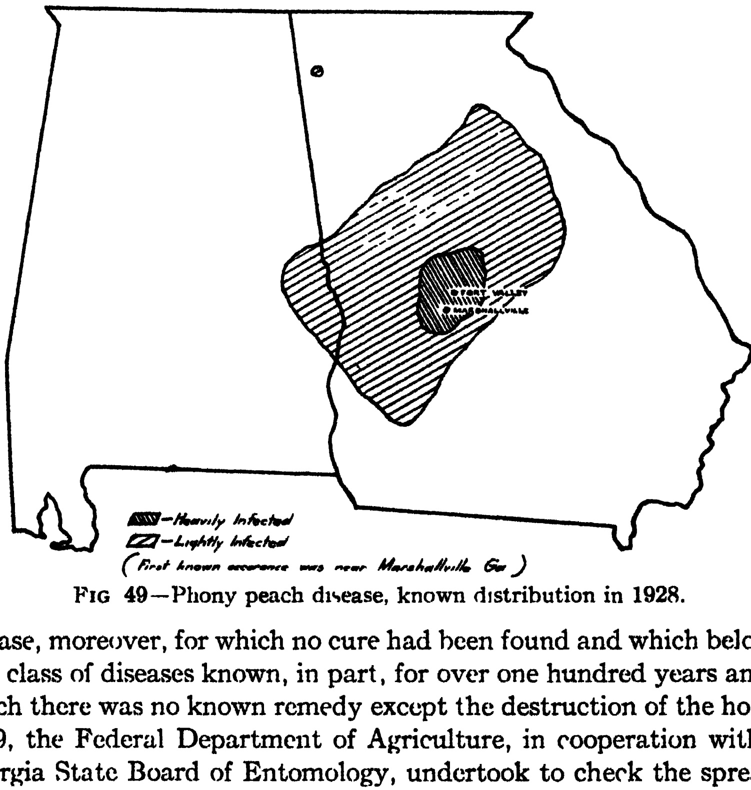

FIG 49—Phony peach disease, known distribution in 1928.

disease, moreover, for which no cure had been found and which belonged to a class of diseases known, in part, for over one hundred years and for which there was no known remedy except the destruction of the host; in 1929, the Federal Department of Agriculture, in cooperation with the Georgia State Board of Entomology, undertook to check the spread of the phony peach disease and, if possible, to eliminate it by means of an eradication campaign

DISTRIBUTION OF THE DISEASE —Preliminary surveys, necessarily limited in extent since only two men were available for the work, had indicated a generally severe outbreak throughout the Southern Peach District of Georgia; a lighter distribution through the Middle Georgia District and only an occasional phony tree in North Georgia. A few diseased trees had also been found in Lee County, Alabama—an area contiguous to the Middle Georgia District. (Fig. 49). Consequently, during most of the first season, work was confined to an attempt to inspect as many as possible of the commercial orchards in the area known to be involved.

Some scouting work, undertaken near the close of the season, brought to light a severe local outbreak in Western Alabama and another in Central Mississippi. Since 1929, therefore, the actual eradication work has been supplemented by numerous surveys that have at least touched all of the commercial peach growing districts east of the Mississippi

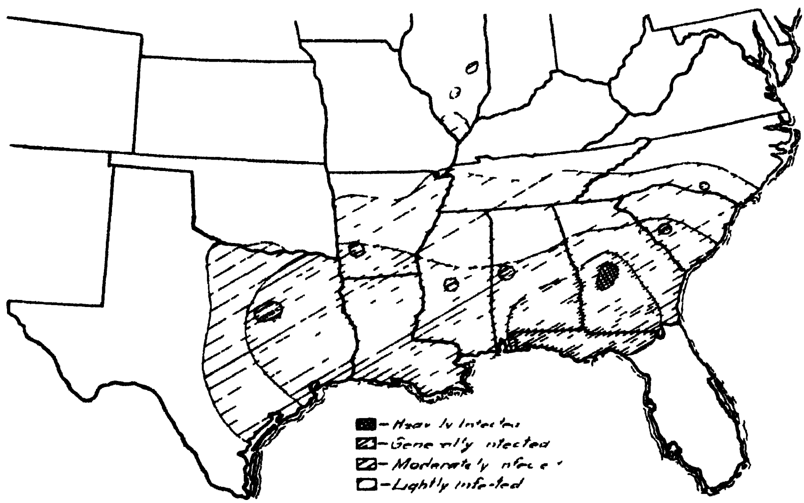

FIG. 50.—Phony peach disease, present known distribution, January, 1, 1932

River as well as those of the states of Louisiana, Texas, Oklahoma, Arkansas, Missouri and Kansas to the west. With such a wide area to cover and with only a limited personnel available for this work, the scouting could not possibly be very intensive. However, it has shown that the disease occurs in at least thirteen states—North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, and Illinois, east of the Mississippi River and in Louisiana, Texas, Arkansas, Oklahoma, and Missouri to the west of it (Fig. 50).

The phony disease is most severe on the Fort Valley Plateau, in Georgia; an area extending from Bibb County on the north to Montezuma, in Macon County, on the south and from Eastern Crawford County, easterly about half way across Houston County. Incidentally this was, until recently, the most intensively planted peach district in the Eastern United States and it was on this plateau that the first phony peach trees were found.

The remainder of the infected territory grades rather satisfactorily itno three regions on the basis of intensity of infection, and we are designating these as Generally Infected, Moderately Infected, and Lightly Infected Territories. In the Generally Infected Territory very few

commercial orchards five years of age or older were free from the disease at the beginning of the campaign and the incidence sometimes ran as high as 25% in individual orchards. In addition, a considerable proportion of the home orchards were also infected. This territory covers Southern Georgia and South Alabama

In South Carolina, Middle Georgia, Central Alabama, Mississippi, Louisiana, Southern Arkansas, and East Texas phony trees are found rather widely scattered, the infection being very moderate, except for a few secondary foci where the incidence may be severe Many commercial orchards in this Moderately Infected Territory are entirely free from the disease and outside of Middle Georgia only an occasional home orchard tree is phony. In certain Middle Georgia counties in this area, home orchards are more severely infected than are the scattered commercial plantings and it is possible that if such commercial plantings were more numerous these counties would have to be classed as Generally Infected.

In the remainder of the infected territory only a few diseased trees have been found, either in commercial or small plantings.

INSPECTION METHODS—In the main, our efforts have been concentrated on the eradication of phony trees from commercial orchards throughout the infected territory. During 1929 we had fifteen inspectors who worked five months, and ten who worked three months. Work was confined to Georgia and one county in Alabama In 1930, thirty-eight men were employed for five months and inspections were extended into Tennessee, Alabama, and Mississippi In 1931, with the same forces, many orchards in North Carolina, South Carolina, Tennessee, Arkansas, Louisiana, and Texas were also covered. During the past season, much the same territory was inspected, but less thoroughly, by a force of eighteen men

We have found that best results follow where the inspectors work in squads of from three to five men—depending on the size of the orchards and their concentration. During the first year, we tagged many of the trees, under an agreement with the owner which stipulated that he would pull them up. The actual removal of these trees was not accomplished, in many cases, until the following winter, and it was necessary to make one or more trips to the orchard in every case in order to obtain a record of such removal. Finding that a very large percentage of the trees die when the main limbs are cut off during the period of inspection (June through October), we now cut all phony trees in this manner. The work takes very little more time than does tagging and saves the cost of tags and the expense of further trips to the infected orchards.

WORK DONE.—Table 1 summarizes the eradication work done each year, listing the number of commercial orchards covered, the number of trees inspected, and the number of phony trees found.

TABLE 1. INTENSIVE INSPECTIONS IN COMMERCIAL ORCHARDS

Year	No. Orchards worked	No. trees inspected	No. orchards found infected	No. phony trees destroyed
1929....	1,472	7,574,304	816	81,042
1930	2,554	11,986,543	1,256	217,084
1931	3,221	9,529,450	659	37,721
1932	1,310	4,786,007	442	34,465
Total	8,557	33,876,304	3,173	370,312

In considering the economic importance of a disease we naturally think in terms of commercial plantings and, as I have stated, our efforts have been devoted largely to the elimination of the phony disease from such orchards. However, from the standpoint of eradication, home orchards and even wild trees may play as important a role as do the larger plantings.[1] In fact, in many counties, our only records of the presence of the disease are based on infections found in such home orchards. More than this, in a few cases, repeated inspections in commercial orchards have indicated the presence of a source outside such orchards, from which the disease was continually re-invading them. For these reasons we have conducted a few intensive home orchard surveys, using a county as a unit, and the inspectors are instructed to stop and cut such phony trees as they may see in home orchards, when traveling from one commercial orchard to another. In general, this work has indicated that from one district to another, the incidence in home orchards varies in about the same way that it does in commercial orchards, the percentage of infection in any one community usually being lower than that in commercial orchards in the same community. However, there are numerous exceptions to this general rule, especially in counties

TABLE 2. INTENSIVE INSPECTIONS IN HOME ORCHARDS

Year	No. orchards worked	No. trees inspected	No. orchards found infected	No. phony trees destroyed
1929......	14	665	4	19
1930.........	5,052	150,047	825	3,391
1931..........	2,127	43,018	290	1,316
1932..........	4,044	89,176	473	1,602
Total.......	11,237	282,906	1,592	6,328

[1]Since plantings vary all the way from one tree to several thousand, no hard and fast line can be drawn between "commercial" and "home" orchards. For various reasons of economy in operation and uniformity in keeping records, we have made an arbitrary division, considering all orchards of less than 100 trees as home orchards and all those of 100 trees or more, as commercial orchards.

where there are thousands of trees in home orchards but where there are very few large plantings. Table 2 summarizes the work done in home orchards.

Table 3 summarizes the results of the scouting work in a similar manner.

TABLE 3. EXTENSIVE SCOUTING

Year	Number observations	Number trees	No. places found infected	No. phony trees
1930..........	8,338	121,579	26	55
1931..........	7,329	2,558,626*	1	2
1932..........	282	7,261	1	1
Total.......	15,949	2,687,466	28	58

*Includes many commercial orchards scouted in 1931.

It should be borne in mind that no comparisons of results can be drawn from Tables 1, 2, and 3, since in no one year have we exactly duplicated the inspections made in any other year. The tables are presented simply as a record of work performed since the beginning of the campaign.

RESULTS.—While we are now able to operate much more expeditiously than was the case at the beginning of the campaign, it has never been possible to cover all of the orchards during any one inspection season. Consequently, comparative figures, showing the results that have been accomplished, can be furnished for only a small proportion of the orchards inspected. Examples are furnished from the two extremes of infection—very light and very heavy.

Table 4 gives the figures for 289 orchards, located in 20 counties in the Lightly Infected Area of North Georgia. In these orchards three years of eradication reduced the number of phony trees 84%.

TABLE 4. REDUCTION OF PHONY TREES ACCOMPLISHED BY THREE INSPECTIONS IN LIGHTLY INFECTED TERRITORY (289 ORCHARDS—629,413 TREES)

Inspection	No. orchards infected	No. phony trees	Per cent decrease yearly	Per cent decrease to date
1929..........	20	44	——	——
1930..........	11	19	56.82%	56.82%
1931..........	6	11	42.11%	75.00%
1932..........	6	7	36.27%	84.10%

During the first year we were not able to reach the most Heavily Infected Area, on the Fort Valley Plateau. Consequently, figures are available for only three inspections, showing the results obtained by two years of eradication. In 127 orchards, located in four counties, we have reduced the number of phony trees 66%, as shown in Table 5.

TABLE 5. REDUCTION OF PHONY TREES ACCOMPLISHED BY TWO INSPECTIONS IN HEAVILY INFECTED TERRITORY (127 ORCHARDS—911,550 TREES)

Inspection	No. orchards infected	No. phony trees	Per cent decrease yearly	Per cent decrease to date
1930	126	50,544	———	———
1931	126	25,793	48.97%	48.97%
1932	121	16,815	34.85%	66.74%

We feel that the figures, as given, indicate that very distinct progress has been made and the results obtained by the second and third inspections are particularly encouraging. From the standpoint of eradication, one of the most outstanding characteristics of the phony disease is its long incubation period. By careful and often repeated experiments, Dr. Lee M. Hutchins of the Federal Bureau of Plant Industry, has shown that after artificial inoculation, performed during the winter months, this period is at least eighteen months long and there is much evidence to indicate that under conditions of natural infection the period is probably extended to at least two years. Hence, following the removal of all positive cases by a first inspection, all of those trees showing the disease a year later had already been inoculated before eradication was started In other words, it was only when we had inspected an orchard for the third time that we had figures that would indicate a definite advance in our control of the disease. In Table 4 it will be seen that in Lightly Infected Territory an average reduction of 42.11% was indicated by the third survey; these results being supported by a further reduction of 36.37% the following year. In Heavily Infected Territory (Table 5) we have obtained an average reduction of 34.85% of new cases to date.

All who are familiar with eradication work will realize that these average figures are by no means applicable to every individual orchard. In a few cases our inspections have indicated a lack of results due, apparently, to constant re-infections from some source outside the orchard under consideration. During the last two years we have been able to survey the territory closely surrounding a few such orchards. In every case we have investigated, we have found one or more groups of trees, either in home orchards or growing wild, rather closely adjacent to the commercial planting and heavily infected with the phony disease.

One case may be cited as an example. In Fayette County, Georgia, we have inspected one orchard of 25,000 trees for four years, commencing in 1929. The orchard was planted in 1926. The first year we found 19 phony trees. In 1930 we found 3. In 1931, at the third inspection, we were surprised to find 119 phony trees. An analysis of the situation showed that all but 26 of these trees were located in the western portion

of the orchard, 53% of them occurring in the first 10 rows. (Fig. 51). We immediately made an intensive survey of home orchards and wild trees, finding 279 phony trees within one mile of the orchard. These

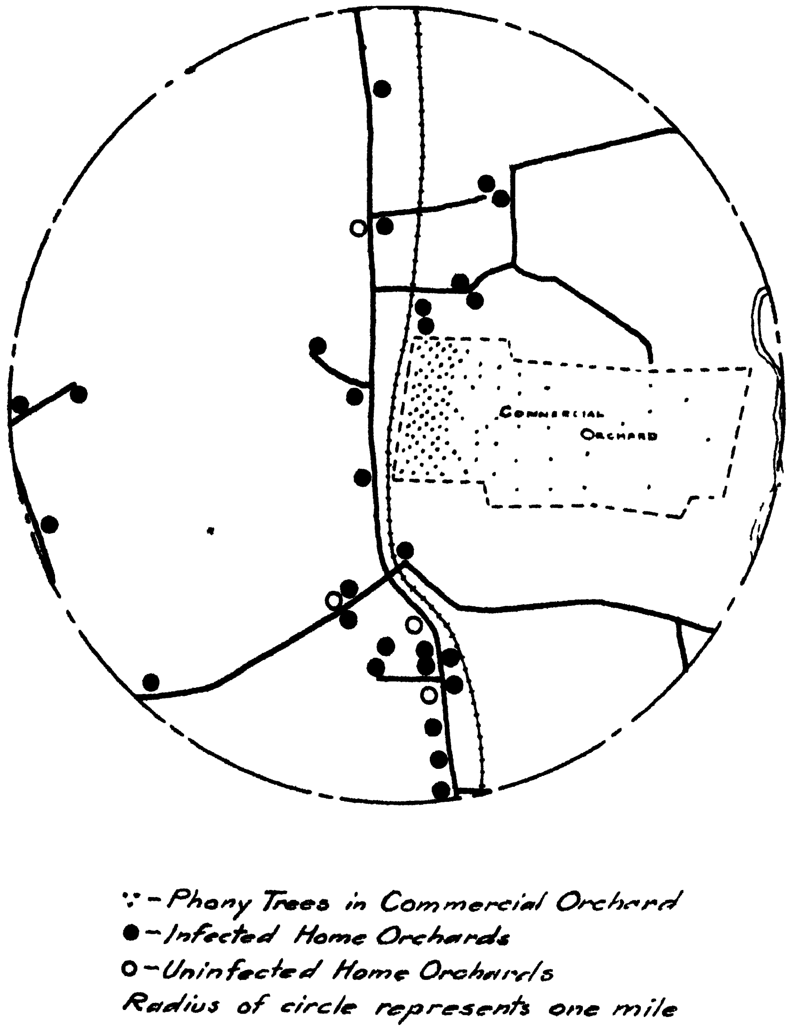

Fig. 51.—Phony peach disease, infection of a commercial orchard from surrounding home orchards.

were destroyed. This year, at the fourth inspection, we found only 42 phony trees in the orchard.

The phony disease situation is a complicated one. Conditions vary

widely in different parts of the territory affected. While commercial control, involving only the larger orchards, is obviously of primary importance, biological control is only possible through the examination of every peach tree in the infected area. Commercial plantings are of very uneven distribution and in many large areas the continuance of the disease is wholly dependent upon infections in small home orchards or even in wild trees. Purely local conditions are frequently of such importance as to produce results entirely out of line with those obtaining in other, apparently similar, areas. Under such circumstances, an attempt to show the exact situation by figures would be confusing. However, our observations, over all of these varying conditions, lead us to believe that there has been a very decided gain of eradication of disease over incidence of disease. While we consider this trend as very definite, the work has not yet progressed far enough to allow us to predict the time when the disease can be completely eradicated.

CHAIRMAN PRICE The report of the Resolutions Committee will be presented by Mr. A. F. Burgess.

REPORT OF THE COMMITTEE ON RESOLUTIONS

Your committee wishes to express the thanks of this Section to the Local Committee for the ideal arrangements that have been made for holding this meeting and to express our appreciation of the interest of the members who in many cases have gone to much personal inconvenience and expense to make the session so successful.

A. F. BURGESS
E. L. CHAMBERS
C. H. HADLEY
Committee

On motion the report was adopted.

CHAIRMAN PRICE: Doctor Britton will present the report of the Committee on Nominations.

MR. W. E. BRITTON The Nominating Committee makes the following recommendations:

Chairman: R. W. Leiby, Raleigh, N. C.

Secretary: S. B. Fracker, Washington, D. C.

W. E. BRITTON
G. M. BENTLEY
Committee

On motion the report was adopted and the officers named declared elected.

The meeting adjourned at 5 o'clock.

Section of Extension, American Association of Economic Entomologists

Friday morning, 9:30, December 30, 1932

The Program was scheduled for 1:30 p. m., but was changed to 9:30 a. m., so as not to compete with the Deciduous Fruit program in the general section, in which many of the Extension Entomologists were vitally interested.

The Committee on Nominations, appointed by the Chairman, consisted of P. D. Sanders, W. E. Blauvelt, and C. C. Wakeland, The Committee recommended, and the section elected as Chairman for 1933, H. E. Hodgkiss, State College, Pa., and as Secretary, M. P. Jones, Washington, D. C.

The Committee on resolutions, consisting of W. A. Price, H. G. Walker, and J. J. Davis, presented resolutions that were unanimously adopted as follows:

Resolutions

Whereas, the arrangements for the meeting of the Extension Section of the Association were most satisfactory.

Be it Resolved, That we express to Messrs. T. J. Headlee, and C. H. Hadley, our deep appreciation of their services in this connection, and to the American Association of Economic Entomologists for their cooperation in providing suitable facilities for the program.

(Signed)

H. G. Walker
J. J. Davis
W. A. Price, *Chairman*

THE ROLE OF THE EXTENSION SERVICE IN COMBATING GRASSHOPPERS

By A. D. Worthington and A. M. Pearson

Abstract

The Extension Service, in cooperation with the Agricultural Experiment Station and the State Department of Agriculture, conducted successful grasshopper campaigns in Iowa in 1931 and 1932. The program adopted and the methods used are briefly described. Commercially prepared poison bran bait was used almost exclusively in the control work. Community cooperation of the farmers in spreading the bait was excellent.

The purpose of this paper is to describe briefly the methods used in controlling grasshoppers and to emphasize the results that may be

secured when the Extension Service, in cooperation with the State Entomologist and Experiment Station, put into operation a well planned and organized grasshopper control campaign.

For several years the grasshopper population has been increasing rapidly in Iowa and in the adjoining states to the west and north. The center of the infestation was probably located in South Dakota. The present outbreak has been largely the result of an over-abundance of two species, the differential (*Melanoplus differentialis* Thomas) and the two striped (*Melanoplus bivittatus* Say) grasshoppers. The red legged (*Melanoplus femur-rubrum* DeGeer) and the lesser migratory (*Melanoplus mexicanus* Saussure) grasshoppers have also done considerable damage. Poison bran bait was used for their control in seventy-one counties.

Conditions during the summer and fall of 1931 were unusually favorable for grasshopper development and permitted oviposition over a long period. Field observations and surveys in the fall of 1931 showed immense numbers of egg masses, particularly in the western part of the state. There seemed very little doubt that a serious grasshopper outbreak would occur again the following year. This prediction was verified in March 1932 when field observations indicated that a large percentage of the eggs had survived the winter without apparent injury.

The first measure taken in 1932 was the formation of a state-wide organization. A state committee consisting of M. G. Thornburg, State Secretary of Agriculture, R. K. Bliss, Director of Extension Service and Dr. C. J. Drake, State Entomologist was appointed. This committee selected the State Entomologist as state leader in the control campaign, who in turn appointed the Extension Entomologist and his assistant to organize, and supervise the field work. In each county the agricultural agent was made county leader to organize his county in cooperation with the Extension Entomologist. In the seriously infested counties a committee, composed of local bankers, newspaper editors, members of civic organizations, directors of Farm Bureaus and other influential persons, assisted the county agent. In communities where grasshoppers existed in great numbers, a leader was selected by the county agent to assist in organizing and conducting demonstrations in his community.

The State Committee secured state funds for purchasing and handling the poison bait and made it available to all counties where organizations were formed for handling the bait. Bids were received from several commercial concerns; contracts were awarded three firms (located in Des Moines, Sioux City, and Omaha respectively) to furnish ready mixed poison bait. The bait used consisted of 80 per cent bran, free of

shorts, 15 per cent black strap cane molasses and 5 per cent finely powdered white arsenic. The county leaders ordered poison bran directly from the State Secretary of Agriculture. The state paid all transportation charges on shipments of five ton lots or more to county and community distributing points. In all communities a local grain elevator company stored and distributed the poison bran without commission or profit. The state sold the poison bait to the farmers and growers at 50 cents per hundred pound bag. This small charge prevented the wasting of the bait and insured care and precaution in its distribution. A farmer who wished to obtain the bait secured an order from his county agent, or from some person appointed by the agent, and obtained the bran from the nearest distributor.

At district meetings held in the early spring the county agents were given detailed instructions relative to their duties during the campaign. Briefly, the duties of the agents were to organize their counties, to give publicity to the program, to make periodic county surveys, to order, store and distribute the bait, to arrange, advertise and conduct field demonstrations, and to make individual calls and interviews with farmers whenever necessary. The cooperation of the county agents and the local committees was very gratifying to the Extension Entomologist and to the State Committee.

Field demonstrations were a valuable means of instructing the farmers; they also served to stimulate them to take early and proper control steps so that a large percentage of the grasshoppers were poisoned on their hatching grounds. For all demonstrations and control in waste areas the bait was furnished free by the state, providing it was applied by the community and the adjoining privately owned fields had been treated. The field demonstrations were advertised through local newspapers, post cards to Farm Bureau mailing lists, posters, and by various other means. Field demonstrations consisted of short talks on grasshopper habits and control, followed by detailed demonstrations on mixing and spreading the poison bait.

Several methods of scattering the bait proved practical. For small areas, sowing by hand while walking, or on horseback, was found to be quite satisfactory. For larger areas an endgate seeder seemed to be one of the most efficient and generally used methods of application. As an endgate seeder was available on nearly every farm, it could be operated without any additional investment on the part of the farmer and the bait could be applied rapidly. The airplane also proved to be efficient in scattering poison bran for both grasshoppers and armyworms in waste areas and on large infested fields.

The proper functioning of the program depended very largely upon the efforts of the Extension Entomologist. His duties were many and varied. It was necessary for him to make field surveys throughout the season and to determine the areas needing control measures. He promoted publicity regarding the program, progress and interesting features of the campaign. Cooperation and interest in the program depended much upon well planned and timely publicity The initial demonstrations in a county were conducted by the Extension Entomologist or his assistant At such demonstrations the county agent and local leaders became familiar with the proper methods of preparing and applying the poison bait It was necessary for him to be in the field continuously to direct the distribution of the poison bran to the counties in accordance with their needs, in order to prevent an excessive carry-over. He was also continually called upon in the field to determine the effects of fungus diseases and parasites and to issue free bran for waste areas. False rumors in regard to the effectiveness of diseases and the ineffectiveness of the poison bran were sometimes started and it became the duty of the Extension Entomologist to investigate such rumors, give an adequate explanation and stop the false rumors. For example, the mayor of a small town in Sioux County, who was also an extensive farmer, secured fungus cultures from a nearby state and some twenty farmers used it. Within a few days after the fungus was introduced reports were published in state and county papers regarding the wonderful results secured by this method. The local promoter of this fungus control project gladly directed the Extension Entomologist to these twenty farms to make an investigation Apparently the fungus had not caused the death of a single grasshopper. The mortality that had been accredited to the fungus was in reality being caused by parasitic flies in a few localized areas. The community immediately obtained a shipment of poison bran and in a short while the grasshoppers were well under control.

The heaviest infestations were somewhat localized in the western part of six counties along the Missouri and Big Sioux Rivers; 250 tons of poison bran bait were distributed in these counties. In this area over 99 per cent of the farmers having grasshoppers in sufficient numbers to cause damage used the bait. Due to early and timely control measures the grasshopper damage did not exceed 10 per cent of the crop in any field. In Woodbury County alone 475 farmers cooperated in distributing poison bran. The control of the grasshoppers was not the only beneficial result of the campaign, as farmers who had not previously been wholly in sympathy with the Extension Service were induced to

cooperate in extension work through the medium of the grasshopper campaign.

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F. D. BUTCHER: Minnesota had an outstanding grasshopper control campaign this past summer. About 56 counties were well organized. The form of organization was similar to that outlined in this paper.

VEGETABLE INSECT SCOUTING IN NEW JERSEY[1]

By ROBERT C. BURDETTE, *Associate Entomologist, New Jersey Agricultural Experiment Station*

Abstract

Systematic scouting of vegetable crops for beginning of insect outbreaks, as practiced in New Jersey, was discussed. The object is to forestall outbreaks and make better control possible. The results secured were discussed, tomato horn worm being taken as an example.

For many years in New Jersey, outbreaks of insects on vegetables have occurred which have caused an almost complete loss to the affected crops in certain localities. A study of these outbreaks has led us to believe that the main cause for the severe losses was due to the lack of information on the early appearance of the insects causing the damage. Usually three-fourths of the damage was accomplished before any real effort to control the insects had been started. The growers should necessarily be made to realize the need for action sufficiently early to

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

prevent serious damage to their crops. The insects in some cases are so small that they pass unnoticed by the grower until the plant crops begin to exhibit physical characteristics of an abnormal nature. Unfortunately, by the time these abnormalities appear half or more of the damage had already been done.

It was with the idea of finding the appearances of injurious insects sufficiently early to enable the grower to protect his plantings that vegetable insect scouting was started. The work did not get under way this past summer until the first week in June. As we have no extension entomologist in New Jersey the writer undertook the scouting work in connection with the research program on vegetable insects.

Two days of each week were allotted to this work and the area to be scouted was confined to the southern portion of the state which is the principal vegetable growing area. The principal objects of the scouting trips were (1) to find the beginnings of insect outbreaks, (2) to follow up such beginnings and (3) to give control information.

The various vegetable crops were gone over carefully for the absence or presence of insects. A comparison was made in relation to abundance of insects each week to that of the previous week This was done by making counts in various parts of the fields. In this way increases and decreases were readily obtainable and comparatively accurate information was then at hand for dissemination. Fields were considered where control measures were applied as well as fields where nothing was being done to prevent the insect damage

After the scouting trip was finished a report was written up containing the information found that particular week This report contained the status of the insects on each crop in relation to the previous week, with recommendations as to control measures and the time when these control measures should be used. This report was typewritten and a copy sent to each county agent in the state and to certain large vegetable growers and canners. The scouting was continued until the last week in August.

The scouting trips gave a very good idea of the insect situation on vegetables throughout the summer. The tomato horn worm has for several years been a serious problem in our state but with this early information we were able to control the tomato horn worm better than in previous years.

As an example of the scouting report, one can take the tomato horn worm. The eggs and small larvae were found on June 20th and 21st and the infestation was in only four of the counties scouted. The report contained recommendations for controlling the insect and also

advised prompt application of control measures. The scouting the following week showed a heavier infestation with more eggs and young larvae, but also larvae 1½ inches long. At this time the horn worm was found on peppers in two counties. The third week found serious damage to unprotected fields with little or no damage to protected fields. Eggs and young larvae were also reported. The fourth week few eggs were found but many larvae ready for pupation were seen. The fifth week showed larvae present but no eggs. Damage was very heavy in unprotected fields, and some damage to sprayed fields where spraying was poorly done. The sixth week showed about the same conditions as the fifth week. The seventh week, August 2nd and 4th, eggs of the horn worm were found in small numbers. The eighth week the scouting found the eggs in larger numbers than the previous week and also young larvae. Prompt treatment of the tomato was then advised for this second brood of horn worms. The ninth week showed eggs and larvae much more numerous than the previous week and considerable damage was present in the field. The tenth week showed many of the worms more than half grown. At this time heavy parasitism was found in one field. No further follow up was made after this time due to other work.

We also had at our finger tips the various stages of other insects during the summer and could then revise our control recommendations to fit the changing conditions. Each county agent then knew the stages and populations of various insects in his county so that control measures were not being stressed until conditions were favorable. The scouting more or less eliminated the haphazard method of sending out service cards on control measures for an insect over the entire state. The service card method as used heretofore to be in time for a certain section of the state has been too early for one section and in other sections too late. With the scouting service, timeliness of spray applications could be greatly stressed.

No attempt was made to organize campaigns against the insect and to follow up control measures only as such came under observation while making the regular scouting trip.

It was felt that organization or campaigns should be carried out by the county agents with such help as was needed when time from other duties was available.

The county agents usually followed up the reports and checked the information themselves. This information was well received and the measures adopted early enough to prevent serious outbreaks.

SPRAY SERVICE FOR VEGETABLE CROPS[1]

By L. H. SHROPSHIRE, *Assistant Entomologist, State Natural History Survey*

ABSTRACT

A spray service developed in the intensive trucking area around Chicago was described. It is carried on in connection with research work, and includes scouting to warn of outbreaks; dissemination of control information by publications, meetings and newspaper articles; and aid in securing dependable insecticides and fungicides.

Losses from insect injury constitute one of the largest items of expense in vegetable production. In Illinois alone it is estimated[2] that this loss reaches a total of four or five million dollars annually.

Since the largest vegetable growing area in Illinois is that around Chicago, in Cook County, it is here that most of the experimental work on truck crop insects is carried on. Headquarters are established at the Cook County Experiment Station, a branch of the Illinois Agricultural Experiment Station, located at Des Plaines in the heart of the vegetable growing area Field work is done in connection with the regular research work on insect pests. The spray service for vegetable crops has developed in connection with field and research work in the northern part of the state, the Illinois Natural History Survey cooperating with the Department of Horticulture of the University of Illinois and its Extension workers. In Cook County, the Farm Bureau under the direction of the Farm Adviser and the Cook County Truck Growers Association, an independent organization of growers, are actively sponsoring the insect control program for vegetables.

Scouting is a part of the regular field activities and has a two-fold objective: (1) that of keeping informed as to insect activity, and (2) that of keeping in touch with the growers and their problems in using the methods recommended to them for insect control. Both phases of this work are very necessary. An average of one day each week is devoted to field work, dividing the time as necessary between scouting and investigating reports of insect injury. Notes kept furnish a record of species, abundance, injury, parasitism, and other natural factors that may be of interest.

The method of reporting insect abundance depends to some extent upon the nature of an individual case. If the insect is a common one that has to be controlled every year, the matter of reporting abundance

[1]Contribution from the Illinois Natural History Survey, Entomology Project Group 7.

[2]Compton, Charles C. Insects Feeding on Truck and Garden Crops and How to Control Them. Ill. Agr. Exp. Sta. Circ. 391: 2. 1932.

is not as important as emphasis placed on proper and timely control methods. In the case of unusual outbreaks that threaten a crop, information may be reported to Farm Advisers or given to a selected group of newspapers in the form of news articles, briefly describing the insect, its habits, and giving the best method for its control.

. Several methods are used in disseminating information for insect control. Bulletins and circulars on insects affecting vegetable crops are valuable and have a wide distribution. News articles are also valuable in some instances in passing timely control recommendations to the growers.

During the winter and spring months insect control schools conducted under the auspices of the Farm Bureau reach many growers. At these schools a research or extension specialist leads a discussion on insect problems and answers questions or discusses problems with growers. The annual Truck Gardeners' School for Cook County is held during the middle of February, one entire day being devoted to a discussion of insect and disease control.

Further than simply making available to its growers information regarding insect abundance and giving recommendations for control measures, the Cook County Farm Bureau has during the past two years sponsored a commercial project which makes available a dependable supply of staple insecticides and fungicides, refusing to handle any that have not been thoroughly tested. This enables the entomologist and extension worker to make recommendations with the assurance that insecticides or spray materials are available and encourages growers to take a greater interest in insect control. The materials are sold at the regular retail price, the object of the organization being, not to cut prices, but to render a better spray service whereby the grower might obtain spray materials and reliable information on insect abundance and control recommendations. This project has met with marked success since its inception, receiving the endorsement and support of growers and research workers, and supplying a definite need in the insect control program.

With the present set-up for experimental, field and extension work in northern Illinois, an effective spray service is available to vegetable growers the usefulness of which will be greatly increased as interest in insect and disease control increases.

NOTES ON EXTENSION WORK AT THE VIRGINIA TRUCK EXPERIMENT STATION

By Harry G. Walker, *Entomologist*

ABSTRACT

The Norfolk station, organized primarily for research, has always kept close to the growers, and does some incidental extension work in giving general advice, and meeting special needs. As example of the latter, 1932 work on harlequin bug on crucifers and red spider on strawberry was cited. Work is done by cooperation with extension agencies and with insecticide dealers; by use of newspaper articles and radio talks; by field meetings, and by answering calls from individual growers.

The Virginia Truck Experiment Station was established at the request of the members of the Southern Produce Company of Norfolk, a farmers' cooperative marketing organization, and of other growers of truck crops in Eastern Virginia. It was organized primarily for the purpose of conducting research on various phases of truck crop production. Provision was made for the publication of a series of quarterly bulletins dealing with the results of the experimental work conducted by the members of the Station staff. These bulletins are sent to a large mailing list of truck growers and others interested in the production of truck crops.

This Station is located in the very heart of the truck crop area of Virginia. Consequently, the Station keeps in very close touch with the growers and their problems. Growers make frequent calls to the Station to talk over their problems and look over the experimental work at the Station and ask for advice on a wide variety of subjects. In addition, whenever an unusual insect pest appears or some other problem arises which they are not accustomed to handling, a large number of the growers make it a practice to call the Station and ask for someone to come to their farms, diagnose the trouble and prescribe the best methods of control.

Specific examples of this service occurred during the outbreak of the Harlequin bug on various cruciferous crops and of the red spider on strawberries this past season. During the outbreak of the red spider last spring, appointments were made with several farmers to be held at their farms on certain dates and it was recommended that they use finely ground dusting sulphur for the control of this pest. These growers immediately notified their interested neighbors and when we arrived to show them how to apply the dust a large group of men were present at each farm and as far as we were able to determine all of them secured good results by dusting with sulphur.

The first reports of the outbreak of the Harlequin bug were received about August 10th. This pest was seriously injuring early fall cabbage and completely killing young kale in some fields. Examination showed that the insects had been breeding in old seed kale fields and in abandoned fields of other cruciferous crops. The host plants in the seed fields were rapidly drying up and dying and millions of third and fourth instar nymphs were migrating, killing all cruciferous crops as they marched, like chinch bugs migrating from wheat to corn fields in the West. Barriers of creosote and plowed furrows were found to be ineffective in retarding the progress of the nymphs. Therefore, it was recommended that all seriously damaged crops or parts of crops be plowed under, thus destroying thousands of these insects and their breeding grounds It was also advised that close watch be kept and all remaining nymphs be hand picked or sprayed with a two per cent soap solution as recommended by Fulton[1] In the meantime, experimental work was started to determine, if possible, a more efficient control than spraying with the soap solution or hand picking. A meeting was held at the Station at which the growers were warned about the seriousness of this pest and urged to take all possible measures to destroy its breeding grounds and thereby prevent further losses from it

In so far as it is possible, it has been the policy of the Station to try to anticipate the problems which are apt to arise and to send out warnings and advice ahead of time so that the grower may be prepared to meet these problems. This has been done in a number of different ways The Station keeps in touch with the Extension Division of the Virginia Agricultural Experiment Station, with the County Agents, especially those in the trucking area, and with other State and Federal officials, and cooperates with them in disseminating information to the growers regarding the possible occurrence and the methods of control of various insect pests. In addition, special meetings are often held at the Station and in cooperation with other agencies in various parts of the State where discussions of insect problems are given.

Field meetings are also held showing the results of experimental work conducted for the control of insect pests, and of other projects in connection with truck crop production, including demonstrations of the arrangement of nozzles and the best methods of applying insecticides for the control of different insect pests.

The Station also cooperates with the local insecticide dealers and

[1]Fulton, B. B. The relation of evaporation to the killing efficiency of soap solutions on the Harlequin bug and other insects. Jour. Econ. Ent. 23 (3): 625–630 (1930).

distributors in order that they may be able to give the growers the best service possible in the way of good reliable products for the purposes desired.

In addition to the work with the growers of truck crops, the Station also receives a great many requests from home owners and small home gardeners and from nurserymen and greenhouse men in Norfolk, Portsmouth, Newport News, and the surrounding territory for information on the identification and control of a wide variety of insects, including many household insects such as termites, powderpost beetles, cockroaches, ants, and many garden, fruit, and shade tree insects, and those attacking ornamental plants.

It has long been the custom of the Station to publish, from time to time in the local newspapers popular articles of special interest to the local growers Recently we have obtained the use of a column in one of the local newspapers in which are published weekly articles of timely interest on various subjects, including entomology.

In addition the Station has arranged, beginning January 15, 1933, to have a fifteen minute broadcast over the radio, each week dealing with subjects of special interest to the home owner and grower of truck crops.

Comments on Vegetable Spray Service

Mr. H E. Hodgkiss We have no organized spray service for vegetable crops, but I am very much interested and wish that any one carrying on a definite spray service would report

Mr. W. E. Blauvelt. New York has a vegetable spray service organized in a few counties which operates on much the same plan as orchard spray service.

Mr. E. N. Cory: I do not see how spray service such as used for orchard insects will work for vegetable insects We are using mimeographed sheets, news articles, radio and personal calls

Mr. W. E. Blauvelt: New York vegetable spray service is based on annual pests such as cabbage maggot, cucumber beetles, etc.

Mr. N. F. Howard: I feel that vegetable growers do not make as much noise as fruit growers, but the need for insect control is just as important.

Mr. R. C. Burdette: The difficulty we have is that growers do not appreciate the potential damage from insects and when the damage occurs the farmers plow under the affected crop and plant another in its place.

MR. N. F. HOWARD: I appreciate that such a situation often prevails, but feel this further emphasizes the need for more educational work among the growers.

MR. C. C. HAMILTON: Under the present condition, farmers often discover outbreaks before the research worker. If an extension entomologist were present he could keep in closer touch with insect outbreaks and get the jump on the grower and the insect damage.

ENTOMOLOGY IN 4-H CLUB WORK- AT CAMPS[1]

By GEORGE D. JONES, *Extension Entomology Specialist, Univ. of Missouri*

ABSTRACT

A study of field entomology in 4-H Club camps has been undertaken and found to serve a good purpose. Missouri has been studying different phases of nature study work for the past three years in its 4-H Club camp work. Each club member was to collect ten specimens of insects, mount them properly, and identify them while in camp. It has been gratifying to know that many other states have attempted this type of work in one way or another. The effect of reaching more people is a point that should not be overlooked in this type of work. Training while in camp was undoubtedly worthwhile and the effects and results in the years to follow will be interesting.

The study of field entomology in 4-H Club camps has been undertaken by the Missouri Agricultural Extension Service and found to serve a good purpose, as well as offer something very much worthwhile for each and every boy and girl in attendance. The nature of the work has a very strong appeal to the boy's or girl's interest in life and outdoor things.

Missouri has been using different phases of nature study work for the past three years in its 4-H Club camp work. Forestry was studied during the summer of 1930, entomology the summer of 1931, and weeds the summer of 1932. During the summer of 1931 ten camps were held where the study of entomology was undertaken and 1,115 members took part.

Each club member was to collect ten specimens from a list of twenty-five of the most important insects likely to be found in any part of the state where the camps were held. Cigar boxes were used for mounting boxes. Record sheets were filled in, giving the life habits of each insect. Illustrated material dealing with the twenty-five insects was posted in a convenient place, usually in the laboratory space, where it could be

[1]Contribution from the Department of Entomology, Missouri Agricultural Experiment Station Journal Series No. 349.

used for additional reference and identification purposes. Each club member attending camp prepared at home and brought with him his mounting box, covering the bottom with corrugated paper. Pins, labels, pencils, record sheets, killing jars and butterfly nets were furnished and taken to each camp by the club agents. Motion pictures of the development of the Monarch butterfly, the mosquito, and a wild west story were used as a night program for one of the evenings.

The boys and girls were divided into two large divisions to receive instructions. There were three one-hour instruction periods each day for the entire camp. The work was so organized that while one of the divisions was with the State Club agents, the other was collecting in the field and would return the next hour and work in the laboratory. Such a division of labor necessitated three one-hour periods of instruction with each alternating and doing the same work at different periods. Each large group was divided into groups of five for field work. Each five were given a killing jar and a net. The killing jar was a pint fruit jar with a clamp lid. Calcium cyanide was used for the killing agency in the jars. Insects were collected, brought in in the killing jars, pinned, studied, and mounted in the cigar boxes in the laboratory. This required considerable thought and individual initiative. Specimens had to be compared, identified properly, and labeled It was surprising to note the speed some of the club members showed in grasping the method of procedure County agents and project leaders assisted with the laboratory work and soon became very proficient in the identification of the common insects. Many of the county agents commented after the camp broke up by saying that the work helped them greatly, as much almost as the boys and girls. Prizes and ribbons were offered to those who did the best work This stimulated interest and caused them to work harder.

It has been gratifying to know that many other states have attempted this type of work in one form or another this past summer. The results they have had will be interesting. Was it worthwhile? Missouri thinks so and within the next year or so will plan such a study again. T. T. Martin, the State 4-H Club Leader, seems anxious to give it again. He feels that it fits into his 4-H Club project fine and offers the boys and girls something that is both recreational and instructive.

Many of the boys and girls who had the work last year have commented to the writer personally that it helped them understand the why of insect control. Most farm boys and girls are eager to study an everyday happening of life, especially if it has an influence on their work. Many have found oftentimes that the limiting factor in their

project work hinges on some insect control measure. They soon learn from their parents perhaps that things have to be planted and handled in such a way, but when they see the small insect pest or understand how a closely, related species develops they have a better understanding of control measures and they appreciate the reason why a certain outline of procedure or recommendation is given. They can be intelligent about a pest and its control It seems to me that a study of this sort will do much toward causing people to recognize the importance of insect control, as well as appreciate the interesting and the nature study side of the field of entomology It should pave the way for 4-H Club insect control projects There seems to be much in this field untouched as yet.

The effect of reaching more people is a point that should not be overlooked in this type of work. The attendance at the ten camps totaled 1,115 boys and girls, leaders, county agents, and home demonstration agents from some forty counties Many visitors came for the evening program and picture show and were at the camp at different times during the progress of the work Approximately one thousand and seventy-five individuals were made acquainted and introduced to entomology for the first time. A great number had vague ideas about what the field of entomology covered and many learned for the first time how insects live and multiply Again, it would be hard to count the number who benefited by the work for every boy and girl took home with him many interesting experiences, as well as some knowledge of a new truth or idea they had grasped. Many of the parents, no doubt, found themselves interested more in the subject than ever before. In a few more years these boys and girls will be taking over the farms or entering business in one way or another and perhaps a few might enter the field of entomology but, regardless of what they do, the training will have been beneficial because insects do not seem to be partial to any particular vocation when it comes to man's ownership of material things. It will be interesting to watch the effect of this type of work as it is more and more developed.

4-H CLUB WORK AND ENTOMOLOGY

By C. O. Hopkins, *Baton Rouge, La*

Abstract

Prior to 1932 all 4-H Club work in entomology was confined to club camps. Last year by using 4-H Club lessons on entomology prepared by the Extension Entomologist, County Agents were able to reach a larger number of their club members with insect control information.

Prior to 1932 4-H club work in Extension Entomology was limited to two or three weeks activity at the summer 4-H club camps where classes on insects and insect control, were conducted. At these camps from 300 to 500 club members were reached. This method was unsatisfactory when the 18,000 club members in the state were considered.

Along with the closer cooperation of the county agents and the parish school officials, came an agreement whereby the 4-H club meetings were to be held on a definite schedule at which time the county agents were to present subjects which they considered worthwhile and timely.

The results of these arrangements together with a ruling of the Director of Extension, stating that the primary duties of the specialists were to train county agents and furnish them the latest information in order that they might be prepared to present worthwhile subject matter at these meetings, were requests from the county agents, to the state Club Leader, for method demonstration outlines adapted to the 4-H club meeting.

Entomological subject matter is admirably adapted to method demonstrations hence a number of demonstration lessons were prepared and submitted to the State Club Leader, Mr. W. C. Abbott, for approval. Outlines on: Garden Insect Control, Fumigation of Rooms and Houses, Stored Grain Fumigation, Peach Tree Borer Control, Scale Insect Control, Clothes Moth Control, Preparation and Use of Ant Poison, and several other lessons were included

The outlines were modeled after those in the high school laboratory manuals used by biology and chemistry teachers. It was thought that in this form much confusion could be prevented and the lessons demonstrated more clearly.

In preparing each lesson Farmers' Bulletins or Extension Circulars were used as reference. This enabled the county agent to have full reference at hand without cost and to pass out bulletins as he saw fit. Questions were prepared and spaced on the back of each outline so a written answer could be given by each club member, thus enabling the agent to check up on the efficiency of the presentation if he cared to.

They were never more than one page long and the outline followed was the same in every lesson.

The outline: 1. Name of Lesson; 2 Summary paragraph; 3. Object; 4. Material, 5. Procedure; 6. Reference.

With Mr. G. L Burleson, then assistant club leader, the Extension

FIG 52—Dusting kit used in garden insect control demonstration

Entomologist visited twelve 4-H clubs in four parishes to present these lessons and observe the response of the club members to this type of meeting.

The Garden Insect Control demonstration, then a timely topic, was given. The presentation was made as simple and practical as possible. The kit shown in the accompanying photograph was used in the demonstration. (Fig. 52).

This kit consisted of a small plunger type dust gun designed to fit a screw top fruit jar The jar then served as a dust container once the gun was attached Five quart jars containing nicotine dust, pyrethrum powder, sulfur, bordeaux dust, and barium fluosilicate made up the remainder of the kit. On each jar the label was self explanatory. As: nicotine dust for sucking insects, or barium fluosilicate for chewing insects.

Approximately 700 club members were reached in four days to say nothing of the biology and vocational agricultural students who attended.

Measuring the results of the 4-H club meetings could not be done. The attention given by the members, their correct answers to the questions asked, and the enthusiasm expressed by the school teachers

and the county agents led us to believe the type of instructions were very satisfactory.

Results of a series of method demonstration – leader training meetings in sixteen parishes this spring, using the same lesson and pest kit, were very satisfactory and gave us a means of checking the efficiency of this type of teaching

In each parish the home demonstration agent called a council meeting. It was attended by two leaders from each community. The demonstration was given and the leaders were taught to repeat the demonstration. With the assistance of the home demonstration agent these leaders gave the demonstration in their respective communities.

Results of these meetings turned in to the garden specialist shows 458 garden club members using insect control for the first time and 175 pest kits prepared.

By charging $31 00 per meeting for the total cost of the specialists and home demonstration agents time, we found that we were able to train a leader for $2.02 and that each practice adopted this year as a direct result of these meetings cost $1.09.

Conclusions. The work has not progressed far enough for any definite conclusions to be drawn Although there are many wrinkles to be ironed out, we are convinced that it is a decided improvement over our first methods, in so far as reaching greater numbers of club members are concerned. We know that such a method as just described fits well into our organization and indications are that the principles used in this set-up will be the same in any future system adopted

J. J. Davis: I am glad this subject was included on the program We all have a wonderful opportunity to stimulate interest in insect study by methods suggested in the papers just presented and we have ample evidence that the influence goes further than to the youngsters, who will be our active constituents a few years hence, for they carry our messages to their parents and the influence benefits the science of entomology in various ways.

In Indiana, we have for the past eight years given insect study work in two or more 4-H Club Camps nearly every year. We have not attempted to have the boys and girls make insect collections for our camps last but three days and we feel that we can secure greater returns by utilizing the short time in other ways. On the first day of the camp we give the boys and girls a general understanding of insect life and an inspiration to learn more about these dominant animals, using for this purpose illustrations, cabinet specimens and live insects. The

second and third days we utilize for field trips and here they see many kinds and stages of insects and the injury they do, and at the same time learn the first principles of observation.

For the past eight years we have also held an insect collection contest at the annual 4-H Club Round Up. This contest has aroused much interest, not only among the boys and girls entering the contest but also from those who see the collections in the exhibit rooms. The last four years we have added an insect identification contest which has been unusually popular, due in part to the fact that the difficulties of bringing a collection from distant points are not present.

At the present time there is a movement among the State Academies of Science to develop Junior Academies or Science Clubs Already a number of states have organized such clubs and the movement will likely spread to practically every state Here is another place where the entomologist can foster and aid young naturalists and add prestige to the science of entomology.

The contacts with the young people by these methods are not intended to make entomologists out of them but to develop in the minds of those who will make up the future generations an appreciation of insect study as a science and as it relates to the well-being of every human individual

SUMMARY OF THE REMARKS BY E. N. CORY

Due to the necessity for adequate local supplies of insecticides and machinery and the fact that the average dealer is uninformed as to the merits of various insecticides and are therefore at the mercy of high-powered salesmanship, most dealers look to their County Agricultural Agents for advice with regard to insecticides that they should stock, particularly in the case of a general outbreak such as that of the Mexican bean beetle The advice of the County Agent in turn must necessarily be predicated upon the information that he receives from headquarters, particularly in the case of insecticides from the office of the entomologist.

Two factors enter into the advice that the entomologist must give to the County Agents and to dealers directly, namely confidence in the manufacturer and knowledge of the performance of the insecticides gained by field tests. Fortunately it has been our experience that we can place confidence in the integrity and sincerity of most of the insecticide dealers. They are seeking constantly to improve their products and to this end cooperate splendidly with all agencies that are seeking to establish by testing the value of the products they offer. The testing

of insecticides is an important part of the activities of any entomologist, particularly when such pests as the Mexican bean beetle appear. In such a case there are some worthwhile compounds offered for control and in the face of this fact it seems rather futile to include such things as Epsom salts in a series of tests, but the ineffectiveness of any insecticide must be established as well as the relative effectiveness of materials and mixtures that might offer reasonable promise of being effective.

In 1929 during the outbreak of the Mexican bean beetle this method was followed most successfully. The relative efficiency of the long series of insecticides tested by Messrs. Sanders and Langford and the results were used very largely as a guide by all dealers in the state in stocking insecticides to meet the outbreak, with the result that there was very little waste of effort and money by the commercial producers of beans either for canning or market. A similar situation with regard to orchard machinery and methods, though based on a somewhat longer time of testing and experience, exists.

On the whole, we believe that there is a mutual confidence established between dealers in machinery and insecticides and the Department of Entomology that works out very satisfactorily and to the advantage of all parties concerned, especially the ultimate users of the insecticides

A COURSE IN INSECTICIDES FOR PHARMACISTS

By J. J. DAVIS, *Purdue University, Agricultural Experiment Station*

ABSTRACT

A course in insecticides for pharmacy students offered by Purdue University, and other efforts of the university to promote availability of insecticides and better understanding of their use by dealers, are described. It is believed this will be a valuable aid to better insect control.

Availability of recommended insecticides is probably as great a need in economic entomology as are methods of insect control. Another important need in every community is a dealer who not only carries recommended materials, but also one who has a general understanding of the fundamentals of insect control. Among dealers in insecticides, the pharmacist is becoming an increasingly important factor. Realizing this fact and that the pharmacist has an unusual opportunity to develop an insecticide trade and profit thereby, the School of Pharmacy of Purdue University requested that the Entomology Department offer a course in Pharmical Entomology or Entomology for the Pharmacist

to the students specializing in Pharmacy. This course[1] was offered for the first time in the fall of 1931 with 27 students. It will be continued hereafter as a regular course in the curriculum of the School of Pharmacy.

We believe this is an important development in insect control and that other schools of pharmacy may well follow this example in preparing men and women for the profession of pharmacy, for certainly, with the hundreds of trade-named insecticides on the market, it is well, at least from the entomologists' point of view, that the druggist understand the preparations he is selling and that he be able to prescribe or fill prescriptions suggested by the entomologist just as he fills prescriptions of the physician Furthermore, he has a wonderful opportunity to develop a trade which will be profitable and at the same time decidedly beneficial to his community. The need of trained men or at least men who have an appreciation and a general understanding of insect control to dispense insecticides becomes increasingly important with the advent of hundreds of trade-named materials, so many of which are worthless or are sold under trade names at exhorbitant prices.

In connection with the course set up for pharmacy students, the Department of Entomology of Purdue University with the generous cooperation and aid of insecticide manufacturers, has developed an excellent exhibit of chemical and trade-named insecticides.

Furthermore, realizing the need of a guide for dealers in insecticides, which includes all pharmacists, the Purdue School of Pharmacy financed the publication of a bulletin on Insecticides and Their Uses [2]

The School of Pharmacy has an extension specialist who maintains a close contact with the pharmacists and through this contact as well as through meetings of sectional or state organizations, the entomologist is able to inform the dealers of new developments in insect control and advise on the materials which should be kept in stock.

We feel that this entire set up of aiding the potential as well as the present dealers in insecticides will be a material aid in insect control and enable the dealer to build up a more profitable trade and at the same time eliminate a great deal of loss to the consumer by providing a source of reliable and recommended materials and minimize the sale of worthless or exhorbitantly priced insecticides.

The needs of the dealer in insecticides include a knowledge of insects and their control, sources of information on insect control, insecticides to be kept in stock, an understanding of chemical insecticides and how

[1]An outline of the course will be provided to those interested.

[2]Bulletin of Purdue University, vol. 32, No. 7, March 1932, Pharmacy Extension Series No. 1.

to recognize reliable trade-named materials. Manufacturers should realize that state and federal entomologists cannot recommend trade named materials and should wherever possible put out insecticides under chemical names and depend on the brand name to support their product. The Food and Drug Administration should give more attention to the labeling of insecticides. The entomologist should maintain a closer contact with the dealer and aid him whenever possible because such aid will be a great benefit to the ultimate consumer.

DIRECTORY OF MANUFACTURERS OF INSECTICIDES, THEIR PRODUCTS AND ANALYSES[1]

By Thomas J. Headlee, Ph.D., *Entomologist, New Jersey Agricultural Experiment Stations*

Abstract

The large number of new insecticides yearly offered for sale, many apparently untried, and the desirability of distinguishing between meritorious and untested products, were discussed. The possibility of a license system was considered. It was urged that the federal insecticide and fungicide board publish findings.

The economic entomologist is today, more than ever before, constantly beset with requests for information on the efficiency of this new spray and that new dust for use against insects which attack man himself, and his plant and animal crops. This condition obtains because the people in general, and the plant and animal growers in particular, are offered every year a large number of apparently new chemical compounds for which great and attractive claims are made. High powered salesmanship is employed by manufacturers and a considerable quantity is disposed of to the ultimate consumer. If the compound works out satisfactorily in the hands of the consumer, the sales effort is redoubled and a new insecticide business is launched. If, on the other hand, the compound in the hands of the consumer is a flop, the formula is changed and the same effort begins anew.

It does not seem reasonable that any considerable proportion of large and apparently new insecticides appearing each year can have any considerable fundamental research back of them. It looks as if chemists have concocted them as possibilities and concerns are distributing them to consumers for testing. The consumer first buys the product, second applies it, and third reaps the benefit or absorbs the

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

loss. Recovery of damages for these losses is exceedingly difficult to secure.

Of course, there are many insecticide concerns that go to great expense and use much time in concocting an insecticide, in exploring the field for its use and in learning its limitations, before it is ever offered to the public. Such procedure is most commendable and should be sound business policy. Nevertheless, this carefully developed and tested product must be sold in competition with similar products brought out overnight with a fractional production expense.

It would seem that there should be some means of giving the concern, taking all this care and trouble, an advantage in this competition. Perhaps, the fact that the product thus carefully prepared will eventually win the confidence of the consumer is in itself sufficient advantage. If not, some form of adequate licensing scheme would have to be developed.

Any really effective licensing scheme would involve a rather fundamental knowledge of insect parasite and host toxication. Of course, the number of known chemical agents for destroying insect parasites without injury to hosts and host materials are limited. Compounds including chemical agents concerning the toxic action of which there is only inadequate information or no information would have to be refused license.

At the outset of this paper the writer pointed out that the economic entomologist is constantly beset by inquiries about the efficiency of each year's crop of apparently new insecticides. Unless he does nothing else and has a large staff he is left hopelessly behind in any effort to test these insecticides.

About the only thing he can do is to secure from the manufacturer's guarantee the nature of the active principle as its appears in his registration, base his judgment upon the known toxication of this active principle, and answer the inquiry accordingly. Sometimes the nature of the toxic principle is not revealed by the registration record. Sometimes the active agent proves to be a material concerning which there are no toxication records.

These facts reveal that the present insecticide market is in a chaotic condition from the standpoint of manufacture and use of insecticides. The immediate need is regularly secured and regularly published information on the performance of this increasing flow of compounds as they come along. The final solution appears to rest in regulation through licensing manufacturers. A well-considered practice of meeting

the immediate need will furnish the basic information for putting the final solution into operation.

Many years ago, when the proposition of the insecticide and fungicide board was under consideration, many of us thought that this proposed federal agency would furnish a constant supply of information on the volume of new insecticides. As a matter of fact this board does test many of these new insecticides as they appear on the market in interstate commerce. These compounds are tested, apparently solely from the standpoint of misbranding, and eventually the nature and results of subsequent court action are published.

The court action records furnish very unsatisfactory information for the working entomologist. Yet it is obvious that many new and important facts concerning the insecticidal efficiency must be disclosed in the course of this testing.

For some reason this board has refrained from publishing its results. I have been given to understand that this is a matter of policy but have never heard any good reason for this policy.

Thus the sole agency, which might meet this need of the working entomologist, is either unwilling or unable to function.

I am not and, I imagine, many others are not as interested in a directory of manufacturers as we are interested in the quality and performance of their products

In these days, when chemical control is so strongly emphasized, why can not the sole agency engaged exclusively in testing insecticides and fungicides give us the advantage of the data which it gathers? Perhaps if we knew the obstacle in the way we could do something to remove it.

May I suggest that a special committee should be appointed to look into this matter and be empowered to do and perform all things practicable to the end that such information be made available for general use?

INSECT PESTS

By J. A. Hyslop, *Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

The insect conditions of 1932 were discussed, with a consideration of weather effects, especially of the preceding mild winter. A number of the principal pests were discussed, notably the grasshoppers in the northern plains, and the increase of several pests on the northern edge of their normal range.

The abnormally mild temperatures that prevailed during the winter of 1931-32 over the greater part of the Eastern and Southern States, followed by severe freezing in March, were probably responsible for many unusual insect developments.

The grasshopper infestation in the Great Plains was more widespread than it was in 1931 but, in general, less severe. Rainy, cool weather in May and June in the southern part of this area resulted in a rank growth of wild vegetation, which reduced the damage to cultivated crops. This weather was unfavorable to the development of young hoppers, and later parasitic flies, and sometimes a fungus disease, further reduced the grasshoppers The most seriously infested areas this year were eastern North Dakota, central South Dakota, northwestern Minnesota, and to a lesser extent northern Wisconsin, and northern Michigan. Another section of somewhat severe damage was reported from north central Nebraska. In the Gulf region and along the south Atlantic seaboard the American grasshopper (*Schistocerca americana* Drury) became unusually abundant late in the season.

The European corn borer did not spread so far as usual this year. Newly infested townships in Indiana, Maryland, Kentucky, Pennsylvania, and Virginia, however, were found this fall. The corn borer is now known to infest portions of the New England, Middle Atlantic, and East Central States, westward to Wisconsin and Indiana, and southward to Kentucky, West Virginia, and the eastern shores of Maryland and Virginia, and the eastern corn-growing provinces of Canada.

The Hessian fly passed the winter with but little mortality over the greater part of the winter wheat belt. Very cold weather during the middle of March, however, was disastrous to the pupae in the eastern part of this area. From Illinois westward a very high percentage survived and, during the spring, heavier infestations occurred throughout this belt than had been recorded in several years.

The chinch bug was troublesome much farther north and east than is usually the case. Reports of damage were received from Pennsylvania,

eastern Ohio, Michigan, Wisconsin, southern Minnesota, and Nebraska, in addition to the normal chinch bug territory which extends from eastern Kansas into northwestern Ohio. It appears that this insect is entering hibernating quarters in larger numbers than it has for several years.

During May the alfalfa weevil was found well established in the San Joaquin Valley in California, in which state this insect was only previously recorded from a few isolated localities, from Lassen to Mono Counties along its eastern border

The green bug developed in threatening numbers during the late winter in the South Atlantic States and Gulf region This, however, did not develop into a serious outbreak, although local outbreaks were reported from west-central Missouri, northwestern Mississippi, and south-central Pennsylvania.

The codling moth survived the winter very successfully As the season advanced it was reported as being very numerous throughout the greater part of the country In Illinois it was more injurious than it has been any time during the past 10 years Cool weather during June materially retarded the infestation in western Washington, but later the infestation was heavier than usual in that State

The San Jose scale continued to increase from the North Atlantic States westward to Illinois, Michigan, and Missouri

The plum curculio emerged from hibernation in the southern part of the Atlantic seaboard later than it had in many years Early in the season it was but moderately abundant over the East Central States, and somewhat more abundant than usual from Kentucky to Mississippi. It apparently went into winter quarters this year in greater numbers than it did in 1931.

The oriental fruit moth emerged late this spring In the East Central States it seems to be increasing in numbers and for the first time was recorded as generally distributed over northwestern Arkansas and eastern Kansas. With the short crop of peaches that matured over the upper part of the southeastern peach belt, the damage was much more serious than would normally have been the case.

The Japanese beetle was discovered this year at several points outside of the previously regulated area. Among these were two points in Maine, six in New Hampshire, three in Vermont, three in Ohio, one in Michigan, three in West Virginia, three in North Carolina, and one in South Carolina.

The vegetable weevil continued to spread northward and eastward during the year. It was found to be infesting the entire northwestern

quarter of Louisiana and the southeastern corner of Arkansas, and, in addition to the territory already known to be infested, to occur well over the western border of Georgia. It was also found in one county farther west in Texas.

The Mexican bean beetle did not very materially advance its known range. It was, however, found for the first time in the States of New Hampshire, Maine, and Illinois, and has moved somewhat farther northward in Vermont.

The harlequin bug was reported as destructive in Maryland, West Virginia, and southeastern Iowa, which points are considerably north of the normal range of this pest.

The banded cucumber beetle was decidedly on the increase in the eastern part of its range, having been reported as troublesome not only in the Gulf region but in South Carolina, Florida, and Georgia.

The boll weevil passed the winter over most of the Cotton Belt in greater numbers than it has in the past seventeen years. Very heavy damage to the early crop occurred throughout the South with the important exception of western Oklahoma and western Texas.

The pink boll worm was discovered this spring in southern Florida and in the autumn a very light infestation was found at three points in northern Florida. This is the first time this insect has been found in the eastern part of the Cotton Belt.

The elm leaf beetle appeared in destructive numbers at many points throughout the Middle Atlantic, New England, and Central States, and there were isolated outbreaks in Kansas and along the Pacific Coast.

The gladiolus thrips was quite destructive to gladiolus at many points throughout the Atlantic States westward to Tennessee, Illinois, and Minnesota.

An unpredecented outbreak of screw worms was reported during October in the Yazoo-Mississippi Delta in Mississippi, occasioning losses in the livestock business of that section.

Forty-one cases of Rocky Mountain spotted fever were reported from the States of Maryland and Virginia up to the middle of August of this year. Heretofore this dread disease of man borne by a tick was known only from the northern Rocky Mountain region.

THE ADVANTAGES OF CONCENTRATING STATE ENTOMOLOGICAL WORK, WITH SPECIAL REFERENCE TO THE REGULATORY AND EXTENSION PHASES

By CLAY LYLE, *Entomologist, State College, Mississippi*

ABSTRACT

The performance of both regulatory and extension phases of entomology and plant pathology by inspectors of the State Plant Board of Mississippi has been satisfactory. The concentration of all entomological activity in one office has resulted in efficiency and economy and prevented duplication and friction.

While serving primarily as a regulatory organization and discharging such duties as nursery inspection, sweet potato inspection, apiary inspection, quarantine enforcement, and others of this nature, the State Plant Board of Mississippi has found it practical and advisable in the control and eradication of various pests to give assistance of a type which might be classed as extension work. As the state has no official extension entomologist, the demands upon Plant Board inspectors for information and assistance have been all the greater.

In visiting thousands of sweet potato growers, Plant Board inspectors are each day asked for control measures for various field, orchard, garden, and household pests. The owners of the hundreds of nurseries at all times expect the inspectors to advise the best control for nursery and greenhouse enemies. Beekeepers expect apiary inspectors to advise them of the best apiary methods and practices. Thousands of others who do not have regulatory contacts with the inspectors call upon them for pest control information and assistance. The inspectors are stationed at fourteen points in the state at present (twenty to twenty-five before the depression), each in charge of a district varying in size according to the amount of work to be done. They are all college graduates with special training and experience in entomology and plant pathology, and in order for the state to secure the greatest possible benefit from them, their work should not be limited or circumscribed by a narrow interpretation of their duties. Although these inspectors have no official extension status, every effort is made to work in close cooperation and harmony with the Extension Department, and several of the inspectors have had offices with the extension farm agents of the counties in which they maintained headquarters. In no sense has the performance of its regulatory or police duties resulted in embarrassing or hindering the Plant Board in its other lines of service to the people.

In addition to the economy and efficiency of the full utilization of

the training and experience of the inspectors by this combination of their duties, several other advantages result from the concentration in one office of the direction of all entomological work in the state. The Entomologist and Executive Officer of the State Plant Board is also the Entomologist of the Experiment Station and Head of the Department of Entomology of Mississippi State College. Farmers orchardists, and truck growers out in the state are not bothered by trying to keep in mind the functions of several related organizations, but regardless of whether they address their complaints or packages of specimens to the State Entomologist, State Plant Board, Experiment Station Entomologist, Professor of Entomology, or merely "Bug Department," they are all received in the same office and handled without any delay, confusion, or friction. One office being responsible for all entomological work avoids the confusion which sometimes results from conflicting recommendations or statements by the different agencies concerned. This system also prevents any duplication of work or friction which might arise from different interpretations or opinions of the duties of the several organizations.

Among other advantages, this concentration results in the keeping of better insect records, the better utilization of insect collections, more economy in office and laboratory space and equipment, a better entomological library and teaching facilities, and a larger staff of workers than would be possible if the limited funds available had to be divided among three or four separate organizations, each with its offices, equipment, and personnel entirely distinct from the others. This unified system has worked well in Mississippi for the past fourteen years, and apparently has been equally satisfactory in the other states where it has been tried.

BIOLOGY AND CONTROL OF *CHRYSOMPHALUS DICTYOSPERMI* (MORG.)

By A. W. Cressman, *Associate Entomologist, Division of Fruit and Shade Tree Insects, Bureau of Entomology, U. S. Department of Agriculture*

Abstract

The biology and control of *Chrysomphalus dictyospermi* (Morg.) is discussed. This coccid attacks certain greenhouse and ornamental plants and tropical and subtropical fruit and shade trees. Data are given on reproduction, development, mortality, natural enemies and host susceptibility. Oil sprays have proved to be an efficient means of control.

Previous to the winter of 1923–24, *Chrysomphalus dictyospermi* (Morg.) was one of the most serious of the scale-insect pests of New Orleans. In sheltered places the insect survived the freeze of that winter, and there has been a gradual increase in its numbers in recent years, although the infestation is not yet as general as formerly. In Florida Moznette (7) reported this coccid as the most destructive pest of avocados, and more recently the scale has been reported as infesting avocado plantings at Whittier, Calif (12).

Starting in 1923, biological studies of this scale, later supplemented by weekly seasonal counts, were conducted in New Orleans. The gradual increase in the scale in the New Orleans district and its menace to avocados in Florida and California have made it advisable to publish the results of these investigations

METHODS —Experiments were carried on in a partly closed insectary, the insects being protected from direct sunlight and rain Scales were reared on the following hosts Satsuma orange (*Citrus nobilis unshiu*), latania (*Latania commersoni*), sago cycas (*Cycas revoluta*), and camphor-tree (*Cinnamomum camphora*). Infestations on each of these plant species as well as on the climbing fig (*Ficus pumila*) supplied rearing material. The scales were scraped from the infested leaves on to a piece of paper, and the active crawlers transferred with a camel's-hair brush to the new host plant Insectary temperatures were recorded by a thermograph checked daily against maximum and minimum thermometers. Daily mean temperatures were calculated from planimeter readings

DESCRIPTION OF STAGES AND VARIETAL DIFFERENCES. -All stages of the insect itself showed a lemon-yellow color, but the appearance of the covering varied considerably, a variation that was in part dependent on age The cover of the immature scales was yellow brown to brown, and semitransparent outside of the exuviae. The older scales showed all gradations from gray to dark brown; in some scales the first exuvia was depressed, in others it formed a nipple-like prominence.

Several varieties of this species have been described—*pinnulifera* (Mask.) (6, p. 208), *arecae* (Newst.) (8, pp. 185–186), *jamaicensis* (Ckll.) (3, pp. 128–129), and *minor* (Berl. and Leon.) (1, pp 346-347). All of these varieties have been based on differences in the appearance of the covering, and in view of the fact that we have observed just such differences in single infestations with no corresponding morphological and biological differences in the insect, these variations in the cover must be considered of doubtful validity as criteria of varietal differences. However, that markedly different strains of this scale do exist is indicated by reported differences in the sexual and reproductive habits.

Moznette (7) states that in southern Florida the insect appears to be parthenogenetic. According to Britton (2, p. 15) the scales in Connecticut are parthenogenetic, bring forth living young, and the males are unknown. In the New Orleans district all the scales studied were oviparous and fertilization was necessary for reproduction.

The Coccidae show great variation in their reproductive habits. Thomsen (10, pp. 3–46) in studies of *Saissetia*[1] *hemisphaerica* (Targ.) and *Coccus*[1] *hesperidum* L. has found two races in both of these species, one always parthenogenetic and one facultatively parthenogenetic. Gabritchevsky (4) working with *Aspidiotus hederae* (Vall.), found both bisexual and parthenogenetic cultures, while Schrader (9) has studied one race of *A. hederae* and found it always parthenogenetic. He suggests that races similar to those in Lecanium may exist, and that Gabritchevsky may have had a population composed of both strains. It is possible that similar conditions may exist with *Chrysomphalus dictyospermi*, with the difference that in some strains females require fertilization for reproduction instead of showing facultative parthenogenesis. Since hermaphroditism has been shown by Hughes-Schrader (5) to be the usual method of reproduction in one coccid, *Icerya purchasi* Mask., cytological investigations would be necessary to determine definitely the type of reproduction in the colonies on which the Connecticut and Florida reports were based.

EGGS AND CRAWLERS.—In the writer's experiments the eggs were deposited and hatched beneath the scale covering. A range in the length of the incubation period of from 1 to 24 hours in midsummer has been observed, indicating that this insect, in common with many other coccids, deposits the eggs at various stages of development. The "crawler" was positively phototropic and negatively geotropic. Records taken at hourly intervals showed a marked diurnal periodicity in the time of emergence of "crawlers" from beneath the parent scale, as may be seen in the following summary:

Hour removed	*Number emerged and removed*
8 a. m.	235
9 a. m.	4,090
10 a. m.	2,390
11 a. m.	820
12 noon	307
1 p. m.	70
2 p. m.	30
3 p. m.	20
4 p. m.	4

[1]Lecanium of Thomsen.

No nymphs were found before 7 a.m., by 8 o'clock a few had emerged, while the peak of the emergence came between 8 and 9 a.m. That this periodicity was not directly a function of temperature within the range studied can be shown by a comparison of the emergence and temperature up to 9 a.m. for the different broods. (Table 1.)

No crawlers emerged before 8 a.m. during September, 1925, although temperatures as high as 28.3° C. (82.9° F.) were recorded, whereas in April, 1924, 3.6 per cent of the total came out from the covering, with no temperatures higher than 23.3° C. (73.9° F.) In each case the peak came during the 8 to 9 o'clock interval, yet at the time of the April brood the hourly temperatures did not average above 25.8° C. (78.4° F.) until 11 a.m This was the minimum 8 a.m. average for the other three broods.

The time between emergence and settling ranged from less than 1 hour to 24 hours, and once the beak was inserted the scale did not move. The streaks of dead tissue sometimes observed, and which, in the case of *Chrysomphalus aonidum* L., have been erroneously ascribed to the scale moving and pulling the beak through the leaves, probably mark the position of the long beak. The positions of the scales were marked immediately after they settled, in numerous cases, and no scales were ever found to move, although the leaves usually showed these characteristic threads of dead tissue.

Duration of Instars.—The female undergoes two molts, after which she is ready for fertilization. The length of the instars was determined from the date that the majority on each plant molted, and this period was then correlated with the mean temperature. No difference in the lengths of the respective instars was found on the four different hosts. The time required for the first instar in both sexes, for the second instar in the females, and for the period from the second molt of the females to the emergence of the first crawlers has been plotted in Figure 53 as a function of temperature. The effect of thermal change was most marked in the lower range, the acceleration decreasing at higher temperatures. In every case the first instar was shorter than the second at equivalent temperatures.

The life history of the male following the first molt was quite different from that of the female Both the insect and the covering elongated during the second instar and feeding ceased after the second molt. After the fourth molt the male became a winged adult and emerged from the covering. Table 2 gives the approximate lengths of the second, third, and fourth instars and of the adult stage up to emergence.

At all temperatures the females had completed the second molt before

TABLE 1. COMPARISON OF EMERGENCE OF CRAWLERS OF *Chrysomphalus dictyospermi* UP TO 9 A.M. FROM FEMALES OF DIFFERENT BROODS

Date of experiment	Per cent of daily emergence		Temperature							
			8 a.m.				9 a.m.			
	Before 8 a.m.	8 to 9 a.m.	Range		Average		Range		Average	
			°C.	°F.	°C.	°F.	°C.	°F	°C.	°F.
Aug. 28 to Sept. 6, 1923	5.0	76.5	25.3–28.6	77.5–83.5	26.2	79.2	27.2–29.1	81.0–84.4	27.8	82.0
Apr. 14 to 23, 1925	3.7	42.4	17.2–23.3	63.0–73.9	21.0	69.8	20.5–25.3	68.9–77.5	23.5	74.3
July 29 to Aug. 7, 1925	3.6	57.7	23.3–27.8	73.9–82.0	25.8	78.4	25.0–30.0	77.0–86.0	27.7	81.9
Sept. 16 to 25, 1925	0.0	56 5	23.9–28.3	75.0–82.9	26.6	79.9	27.8–29.4	82.0–84.9	28.4	83.1

the males had emerged, but since all stages are present at one time, this does not appear to be of any importance in insuring fertilization

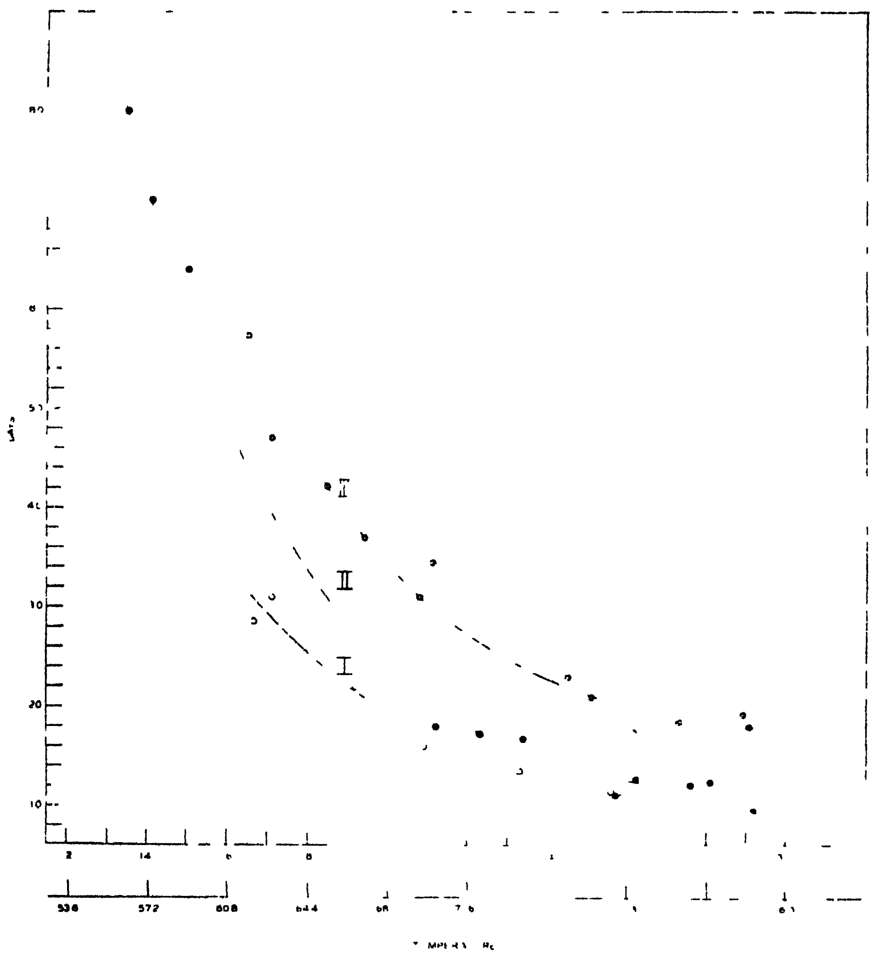

FIG. 53.—Relation between temperature and length of developmental stages of *Chrysomphalus dictyospermi* (Morg.). Curve I represents the first instar of both sexes; II, the second instar in the females; and III, the period from completion of the second molt in the females to emergence of young.

TABLE 2. APPROXIMATE LENGTH OF INSTARS OF MALE *Chrysomphalus dictyospermi*

Second instar			Third instar			Fourth instar			Adult (to emergence)		
Days	Mean temp.		Days	Mean temp.		Days	Mean temp.		Days	Mean temp.	
	°C.	°F.		°C.	°F.		°C.	°F.		°C.	°F.
74	13	55.4	6	19	66.2	10	15	59	4	21	69.8
15	22	71.6	3	23	73.4	4	23	73.4	3	24	75.2
11	28	82.4	1	25–28	77–82.4	3	27–28	80.6–82.4	3	27–28	80.6–82.4

of the females. The same relation in the length of the life cycle of the two sexes has been observed in *Pseudaonidia duplex* (Ckll.) and *Chrysomphalus aonidum* (L.).

The sex was recorded for 2,219 scales and it was found that 54.8 per cent were males and 45.2 per cent females. As between the sexes there was no difference in the position of settling, although with the host plants studied more scales settled on the leaf than on the stem, and more on the upper side than on the lower side of the leaf. Scales were seldom found on the lower surface of palm leaves.

MORTALITY AND PRODUCTIVITY.—The mortality of the crawlers on different hosts from the time they were transferred until they settled is found by subtracting the per cent which settled, as given in Table 3, from 100 per cent.

TABLE 3. SETTLING OF CRAWLERS OF *Chrysomphalus dictyospermi* TRANSFERRED BY BRUSH TO INDICATED HOST PLANTS

Host	Number of crawlers transferred	Number settled	Per cent settled
Latania	2,360	1,819	77.1
Camphor	959	714	74.5
Cycas	507	293	57.8
Satsuma	1,492	1,077	72.2

The percentages of survival of the later stages in the insectary are given in Table 4.

TABLE 4. SURVIVAL OF THE DIFFERENT DEVELOPMENTAL STAGES OF THE FEMALE FOLLOWING SETTLING AND FORMATION OF THE SCALE COVER

The first instar included both males and females; later stages were females only. The number of females settling was estimated by multiplying the total number by the proportion of females given above, 0.452. The number of second-instar females was calculated in a similar way from the total number of scales completing the first molt

	Survival of immature stages				Survival of females from settling to reproducing	
Host	Number settled	Per cent which completed first molt	Per cent first instar females which survived first and second instars	Per cent second instar females which completed second molt	Estimated number which settled[1]	Per cent which reproduced
Latania	369	85.4	79.6	93.0	450	59.0
Camphor	445	80.4	34.8	43.2	89	34.8
Cycas	119	—	—	—	110	60.4
Satsuma[1]	479	77.0	57.6	74.9	408	36.3

[1]These include a part of the scales listed in the immature survival, and some additional ones.

Records on reproduction were obtained from periodic removals of newly emerged nymphs on potted plants infested with a known number of females. At the time of examination some nymphs had settled and started to form covers while others were still active crawlers, some of which would not have settled. The data, therefore, lead to estimates lower than the actual egg production but somewhat higher than the number settling and forming covers. The summaries are given in Table 5.

TABLE 5. PRODUCTIVITY OF FEMALE *Chrysomphalus dictyospermi* ON VARIOUS HOSTS

Host	Number of females	Number of progeny	Average per female
Latania	21	839	40.0
Camphor	71	3,847	54.2
Cycas	47	2,686	57.1
Satsuma	35	3,501	100.0

The figures on latania include 5 single females which produced an average of 50 young, the variation ranging from 20 to 79 per female.

The relative susceptibility of these hosts can be estimated, from Tables 3, 4, and 5, on settling, survival, and productivity, by calculating the number of progeny which would be expected from 100 crawlers set out on each host and permitted to mature and reproduce. (Table 6.)

TABLE 6. PROGENY EXPECTED FROM 100 CRAWLERS OF *Chrysomphalus dictyospermi* ON RESPECTIVE HOSTS. IT HAS BEEN ASSUMED THAT 45.2 PER CENT OF THESE CRAWLERS WERE FEMALES

Host	Number of female crawlers	Number of females settled	Number of reproducing females	Progeny next brood
Latania	45	34.8	20.5	820
Camphor	45	33.7	11.7	634
Cycas	45	26.1	15.8	902
Satsuma	45	32.6	11.8	1,180

On cycas, the high survival after settling compensated for the high mortality of crawlers, while the reproductive rate on Satsuma gave the highest progeny of all in spite of the low survival between settling and beginning of reproduction. On the first three hosts this estimate agrees with qualitative field observations, heavier infestations being found on cycas than on camphor. The scale has not yet become established in the citrus growing sections of this State, but the foregoing data show that it might be a serious pest of Satsuma under Louisiana conditions.

SEASONAL HISTORY AND NATURAL ENEMIES.—In the insectary from five to six broods a year were produced. In the counts made from the field, however, all stages of the insect were found throughout the year, so it was not possible to separate the different broods of the insect. Hence no check on prediction of succession of stages in the field can be

made from insectary data, nor would such prediction have any value from the standpoint of control practices.

The insect is attacked by a number of natural enemies, the following parasites having been recovered: *Aphelinus chrysomphali* (Mercet), *Prospaltella aurantii* (Howard), *Signiphora merceti* (Malenotti), and *Signiphora flavopalliata* Ashmead.

In contrast to the camphor scale, which is usually killed in the second instar when parasitized, *C. dictyospermi* is ordinarily not killed until it has produced some young. Thus 5 parasitized females in the insectary produced an average of 20 young per female. Parasites, therefore, are not very effective agents of control. The coccinellid beetles *Rhizobius debilis* Blackburn and *Lindorus lophanthae* Blaisdell, although not generally distributed, are more efficient and attack all stages. In 1926, an infestation on a Cycas which was being used for seasonal-history counts was completely destroyed by predators.

Table 7. Specifications of Sprays Which Gave 100 Per cent Control of *Chrysomphalus dictyospermi* on Indicated Hosts

Oil specification	Emulsion type	Oil concentration in spray Per cent	Scale host
1. Density, 0.894 Viscosity, 208 secs. (Saybolt) Volatility (4 hrs. at 105°C. or 221°F.), 0.1 per cent Unsulphonated residue, 60%	Oil, 2 gals.; potash fish-oil soap 2 lbs.; water, 1 gallon; boiled and pumped	1	Podocarpus
2. Density, 0.845 Viscosity, 86 seconds (Saybolt) Volatility (4 hrs. at 110° C. or 230°F.), 1.58 per cent Unsulphonated residue, 97%	do	1	Cycas revoluta
3.[1] Density, 0.883 Viscosity, 102 secs. (Saybolt) Volatility (4 hrs. at 110°C. or 230°F.), 0.16 per cent	Potash fish-oil soap and fusel oil, cold stirred (*11*)	1.3	Latania commersoni Citrus sinensis

[1]The third oil was applied by W. D. Whitcomb.

Counts were made from another infestation during 1927 when the natural mortality averaged around 45 per cent in the winter and from 15 to 30 per cent during the rest of the year.

Artificial Control.—The scale is easily controlled by spraying with oil emulsions. Tests with the following oils (Table 7) have given 100 per cent mortality:

All of the foregoing sprays were applied with a bucket pump at about 50 pounds' pressure. The second emulsion showed an average drop size of 5.78 ±24 microns, with a maximum drop size in 273 droplets counted of 21.5 microns. Drop counts were not made on the others, but the first was prepared in identical manner while those of the type of the third were generally more stable than the standard boiled emulsions. All these sprays were applied in the summer without injury to the plant.

Summary

Biological and control studies on *Chrysomphalus dictyospermi* (Morgan) are reported.

No evidence was found for the existence of the varieties which have been described.

The range in the length of the incubation period indicates that the eggs are deposited at various stages of development.

The emergence of crawlers from beneath the parent scale showed a marked diurnal periodicity, the peak of emergence occurring between 8 and 9 a.m.

The rate of development was found to be largely a function of temperature.

No difference in the lengths of the instars was found on four different hosts, but data on survival and productivity indicated that susceptibility to the scale would be in the following order· Satsuma orange, Cycas, Latania, camphor.

More males than females were produced, and fertilization was necessary for reproduction.

In the insectary from five to six broods a year were produced In the field all stages are present throughout the year, and distinct broods can not be distinguished.

A number of parasites have been observed to attack the scale, but these are not effective agents of control, since usually the scale is not killed until after it has produced a considerable number of young. More effective but not generally distributed are the coccinellid beetles *Rhizobius debilis* Blackburn and *Lindorus lophanthae* Blaisdell, which attack all stages.

One hundred per cent mortality was obtained in sprays with oil emulsions, with oils of widely different character, using from 1 to 1 3 per cent of oil.

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THE PHASES OF THE ROCKY MOUNTAIN LOCUST *MELANOPLUS MEXICANUS* (SAUSSURE)

By Jacobus C. Faure,[1] *Professor of Entomology, University of Pretoria, South Africa*

A Foreword

Dr. Faure has shown experimentally (1932) that the brown locust, *Locustana pardalina*, of South Africa exists under two phases, the solitary phase and the swarm phase. Each of the individuals of the solitary phase, which live in isolation like most

[1]The author wishes to make grateful acknowledgment to the Carnegie Corporation for a grant to cover the expense of this work; to Professor Ruggles of the University of Minnesota for laboratory facilities; to Dr. J. R. Parker and his associates, R. L. Shotwell and F. A. Morton, of the United States Bureau of Entomology for aid in locating eggs of *mexicanus;* to A. N. Caudell and James A. G. Rehn for the privilege of studying material in the collections of the Philadelphia Academy of Natural Sciences; to R. H. Nagel as part-time assistant and to Miss Louise Fulton who undertook the preparation of the colored drawings reproduced herewith.

common grasshoppers, is a representative form of the phase *solitaria*. Each of the individuals of the swarm phase, which come together in great dense swarms and then migrate over the country, is a representative of the phase *gregaria*.

The nymphs of the phase gregaria differ markedly from the nymphs of the phase solitaria in coloration, while the adults of gregaria differ in several morphological characters from the adults of the phase solitaria. Dr. Faure, by means of an ingenious series of experiments, has been able to transform the progeny of the solitaria phase into the phase gregaria. There is, therefore, now no doubt of the fact that the transformation of this grasshopper from one phase into the other phase occurs in nature when the conditions are present to bring it about.

It has been suggested recently by several authors that our Rocky Mountain locust *Melanoplus spretus*, now apparently extinct, was the long winged migratory (*gregaria*) phase of our common grasshopper *Melanoplus* (*atlanis*) *mexicanus*. Dr. Faure conceived the idea of attempting, by his experimental methods used so successfully with the brown locust of South Africa, to transform *M. mexicanus* which he surmised to be the *solitaria* phase into *M. spretus*, the phase *gregaria*. The following paper embodies the results of Dr. Faure's observations on *M. mexicanus* in rearing experiments carried out at Saint Paul, Minnesota, during May, June, and July 1932.

GLENN W. HERRICK

MATERIAL AND TECHNIQUE.—During the summer of 1931 there were serious outbreaks of grasshoppers in Minnesota, North Dakota and adjoining states, but *M. mexicanus* was not known to have occurred anywhere as the predominant species. Early in the spring of 1932 I made enquiries with a view to locating egg deposits of this species, but unfortunately neither the Federal nor the State authorities had any detailed knowledge of places in which eggs could be obtained. Under the guidance of Dr. Parker I went to Minot, North Dakota early in May, and collected about 8–9,000 eggs of what we hoped were *M. mexicanus*. Some of the eggs were already hatching, therefore they were packed on ice for transportation to Saint Paul. Unfortunately it transpired a few weeks later that about 95 per cent of the nymphs hatching from these eggs were those of *Melanoplus packardi* Scudder, one of the less important pest species whose eggs are apparently indistinguishable from those of *mexicanus*; the result was that I had only a few hundred nymphs of *mexicanus* to work with.

The collection of newly hatched nymphs was also seriously considered, but owing to the limited time and facilities at my disposal no serious effort was made in this direction. As with the collection of the eggs, one was faced with the difficulty of not knowing just where to look for *mexicanus*, and in addition there were the factors of uneven hatching of the eggs, and the difficulty of distinguishing the nymphs from those of some of the other Melanopli. If the need had been for nymphs of the fourth or fifth instars, this method would have been worth while, but for my purposes I had to have nymphs of the first instar.

In general the methods followed in the rearing experiments, and the cages used, were the same as those recently employed and described by the writer (Faure 1932). Owing to the small numbers of *mexicanus* available, the "crowds" were reared in a new type of small rectangular cage made of wood, celluloid, wire gauze and glass. Two sides and the top were made of celluloid with the idea of forcing the insects into close contact with one another by reducing the area of vertical walls on which they could walk; experience showed that the celluloid was of no value in this direction, for the nymphs walked on the celluloid sides almost as readily as on the wire gauze, even in the fifth instar. In the case of the African species only first instar nymphs were able to walk on vertical glass or celluloid. These celluloid cages were about 6 inches high, and the dimensions of their floors were about 3 by 4½ inches. Owing to the small size of the first instar nymphs the wire gauze used in all types of cages was material of 18 meshes to an inch.

The eggs were placed on moist sand in fruit jars, and kept in an incubation chamber at a constant temperature of 32° C. No attempt was made to control or record the conditions of temperature and humidity under which the rearing was done. During the day-time the cages were kept outdoors in sunny, warm weather. At night and on cool or rainy days, they were placed in a greenhouse that was usually heated to about 80-90° F. in the day-time. Towards the end of the rearing period, in July, there was a spell of very hot weather, with shade temperatures up to 100° F.; during this period the cages were kept in the greenhouse because the heat seemed to be more endurable there (at least to the observer!) than outdoors. The food consisted mainly of young wheat and maize leaves.

THE DIFFERENCES BETWEEN THE PHASES *gregaria* AND *solitaria*.—In

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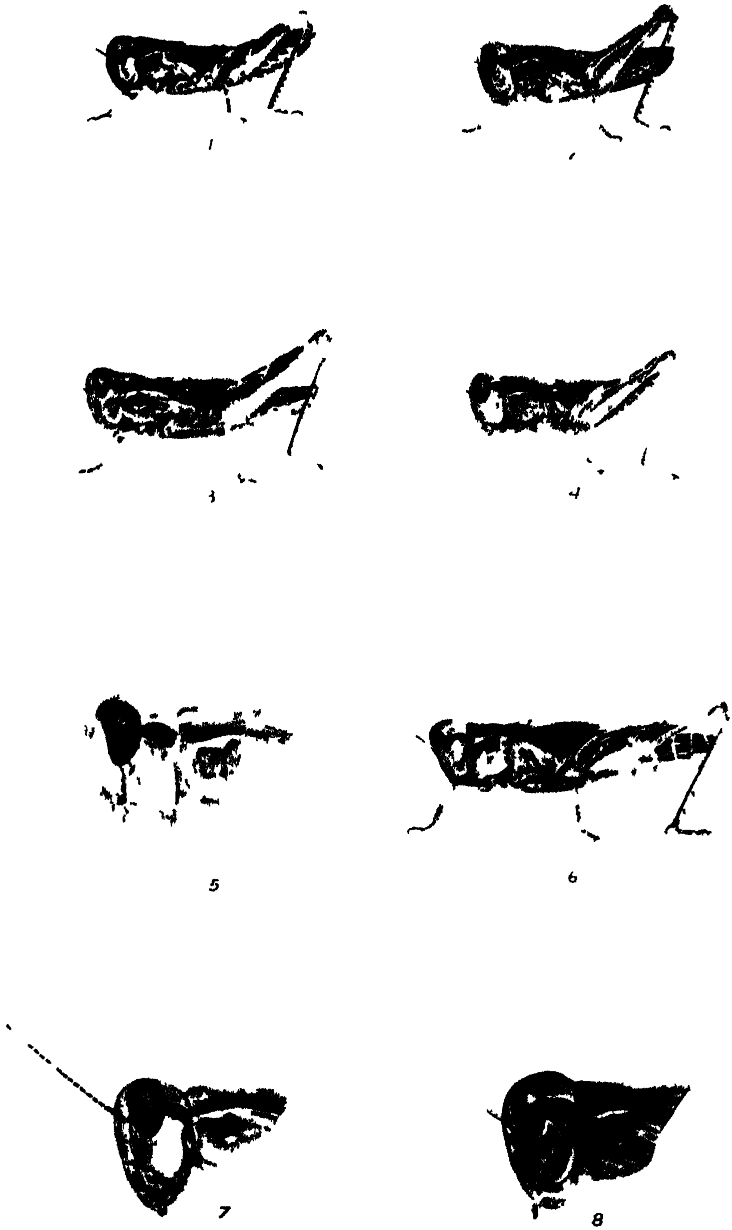
EXPLANATION OF PLATE 29

Melanoplus mexicanus (Saussure)
Louise Fulton del.

1. ph. *gregaria* ♀ 4th instar, from cage containing a crowd (x 2)
2. ph. *solitaria* ♀ 4th instar, reared in isolation in a wire gauze cylinder (x 2)
3. ph. *gregaria* ♀ 5th instar, from cage containing a crowd (x 2)
4. ph. *solitaria* ♂ 5th instar, reared in isolation in a celluloid cylinder on growing wheat (x 2)
5. ph. *solitaria* ♀ 5th instar, reared in isolation in box painted white (x 4)
6. ph. (?) *gregaria* ♀ 5th instar, from cage containing a crowd (x 2)
7. ph. *solitaria* ♂ 5th instar, reared in isolation in box painted yellow (deep chrome, Ridgway) (x 4)
8. ph. (?) *transiens* ♂ 5th instar, reared in isolation in box painted brown (auburn, Ridgway) (x 4)



Jas. Fulton del

Melanoplus mexicanus (Saussure)

the African species of migratory locusts very striking differences in nymphal coloration are known to occur, depending upon the density of the population both in the field and in breeding cages. The phase *gregaria* is characterized by a definite, constant pattern of orange and black, whereas the phase *solitaria* shows a great variety of colour types such as gray, brown, green and various kinds of variegated patterns (Faure 1932, coloured plates).

The excellent black and white illustrations published by the United States Entomological Commission (1878, first report plates I and III) show very clearly that the differences between the forms *spretus* and *mexicanus* (=*atlanis*) in nymphal coloration are of the same order as the differences between the phases *gregaria* and *solitaria* in the African species The figures of *spretus* nymphs show much more solid black on the pronotum than those of *atlanis*. In comparing the two forms, the Commission states that *spretus* has the most black and that its black face is quite characteristic, but no special mention is made of orange as a characteristic feature of this form.

The coloured figures reproduced herewith represent the differences between the phases of *M. mexicanus* as observed in the rearing experiments described below. The characters differentiating the nymphs of the phase *gregaria* are

1) the larger black areas on the pronotum and the hind femora which are solid black in typical examples,

2) a strong contrast between the black and non-black areas of the head and pronotum; the non-black portions may be orange, yellow, pale gray or almost dirty-white,

3) the black face, seen mainly in nymphs of the second, third and fourth instars.

The *solitaria* nymphs are very variable, but they lack the large pitch black areas and their general colour tends to be a kind of gray or brown mottled with black specks; they lack the strong contrast between the black and orange (or pale gray) of *gregaria*. It should be noted that the subdorsal black areas on the pronotum tend to persist in some types of *solitaria* nymphs; on casual examination some of these nymphs could be mistaken for *gregaria* nymphs, but examination under a hand lens will show that the subdorsal "black" areas are not solid black, and often the appearance of black is due to a large number of brownish spots close together. In some of the *solitaria* nymphs a certain amount of black was also found to persist on the hind femora and on the wing-pads.

The phase *transiens* is difficult to define, even in the African species in which the differences between the phases *gregaria* and *solitaria* are

well known; in the case of *mexicanus* my limited experience did not enable me to recognize the phase *transiens* with any degree of certainty. Nymphs showing a development of black more or less intermediate between *solitaria* and *gregaria* were described as *transiens*.

At Lockhart, Minnesota about 75 nymphs were collected on June 29, 1932 with the adults listed in Tables 2 and 3. About 75 per cent of these showed good *gregaria* characters, and the rest were considered as representing *transiens* types.

Nymphs Reared in Crowds.—As the nymphs hatched they were transferred from the egg jars to the rearing cages Some were reared in isolation, as described below, and the rest were kept together in order to note the effects of crowding. The number of nymphs obtained, about 7,500 to 8,000, was sufficient to fill several of the larger cages of wood and wire gauze (size 18 x 9 x 15 inches), consequently four of these and three of the "new" celluloid type (size 6 x 3 x 4½ inches) were used for the material hatching from eggs brought in from the field

When the nymphs were about two weeks old I realized that the great majority were *M. packardi,* those of *mexicanus* were therefore caught out of the seven cages and placed together into two of the small celluloid cages. At this time the *mexicanus* nymphs were mainly in their third and fourth instars, and some of them had already reached the fifth instar. It follows that the insects had completed about one-half of their nymphal development before they were placed together in "pure-culture" crowds consisting of *mexicanus* only They lived under crowded conditions throughout their nymphal life, but the quality of the resulting activity was undoubtedly not the same during the first half of their development as it was during the second, because the nymphs of *packardi* are definitely less active than those of *mexicanus*

The details concerning the cages containing both species are not of sufficient interest to include here, therefore only the crowds of *mexicanus* will be briefly discussed. Into cage No. 103 (size 6 x 3 x 4½ inches) we put 111 nymphs on June 13th, all in the fourth instar; about 78 per cent were described as having black faces and being of the *gregaria* type, and 22 per cent as being more or less of the *solitaria* type. On June 24th there were only about 50 nymphs left, all in the fifth instar, and these were described as showing about 90 per cent *gregaria*, with orange and yellow in addition to more or less solid black markings. By July 13th all the nymphs had become adults; 39 adults from this cage were measured for biometrical data as described below.

Cage No. 107 (size 6 x 3 x 4½ inches) received 200 nymphs on June 13th, of which 145 were in the third instar, 25 in the fourth, and 30 in the

fifth instar; about 76 per cent of these nymphs were described as *gregaria* and 24 per cent as *solitaria*. On June 24th about 60 nymphs of the third to the fifth instars remained alive in this cage, and they were described as about 50 per cent *gregaria*. Out of this cage 42 adults were measured.

In addition to Nos. 103 and 107 there were two other crowds in celluloid cages of approximately the same size. Cage No. 1 contained a mixed lot of nymphs collected in their first and second instars in the field on May 13th to 16th; about 400 were originally placed in this cage, and 36 adult *M. mexicanus* were recovered from it for measuring. Cage No. 144 received about 130 nymphs of *mexicanus* picked from a mixed lot of Melanopli received from Mr. R. L. Shotwell from South Dakota; 44 adults from this cage were measured. In both No. 1 and No. 144 about 50 per cent of the nymphs of *mexicanus* developed a type of coloration that was distinctly *gregaria* in character.

In all cages containing crowds of nymphs of *mexicanus* there was distinctly more activity than in the cages containing single individuals, but the crowd activity was exceedingly poor compared with that of *Locustana pardalina* (Walker) and *Locusta migratoria migratorioides* Rch. and Frm. Even on very hot days in bright sunshine I never saw the kind of continuous jumping in *mexicanus* that is so characteristic of the nymphs of these two African species when reared under crowded conditions. The *mexicanus* nymphs walked up the sides of their cages more or less actively in hot weather, and they displayed a certain amount of quarreling over food; their activity was approximately the same as that observed in nymphs of *Schistocerca gregaria* (Forsk.) in cages in South Africa.

Nymphs Reared in Isolation. Experience in rearing *Locustana pardalina* has shown that the effects of an isolated existence can be studied satisfactorily only when not more than one individual is confined in a cage. In all the experiments with *M. mexicanus* this principle was strictly adhered to.

Three types of cages were used in the isolation experiments: (1) cylinders of wire gauze, size about 6 x 3 inches, tacked to a piece of board; (2) cylinders of celluloid, size about 7 x 3 inches, covered with calico and pressed into soil over growing young wheat plants; (3) painted wooden boxes, size 6 x 3 x 3 inches, with glass lids running in grooves.

The nymphs were placed in isolation a day or two after hatching; when deaths or losses due to other causes occurred replacements were made with nymphs from cages containing crowds, but about ten days after the eggs had all hatched there were no more nymphs of the first

instar available, therefore some individuals were not isolated until they had reached the second stage.

A total of 70 nymphs were reared in the three types of cages and taken into consideration in evaluating the effects of this kind of existence; of these 48 were in isolation from the first to the fifth instar, 6 were reared from the first to the fourth instar, and 16 from the second to the fifth instar. These 70 nymphs were classified in their fourth or fifth instars as follows

solitaria 61 or about 87 per cent
? *transiens* 9 or about 13 per cent
gregaria none

ATTEMPTS TO PRODUCE GREEN NYMPHS. The celluloid cylinders over growing wheat plants were used in order to note whether rearing in this type of environment would result in the production of green nymphs. Only three nymphs of *mexicanus* developed a distinctly green coloration in these cages, out of a total of 33 reared in them, and a fourth was described as greenish yellow, this means that approximately 9 per cent of the nymphs became green when reared in a moist atmosphere on a constant and abundant supply of succulent food The nymphs referred to as being green were similar to those of *L. pardalina* in that only certain parts of the body became green, the dark markings such as those on the pronotum and hind femora that are characteristic of the species usually persisted on the green nymphs as well as on the grays and other types of *solitaria* nymphs.

Out of 75 nymphs of *mexicanus* collected at Lockhart, Minnesota, under outbreak conditions[2] on June 29th, 7 were found that were distinctly green, i.e., again about 9 per cent. The conditions under which these nymphs developed had not been observed before June 29th, but on this date there was still an abundance of green food and a moderately dense growth of weeds and grasses, therefore I assume that the conditions had been favourable for the development of the green colour. The occurrence of about 9 per cent green individuals in a random field sample, and the production of 9 per cent green nymphs in the celluloid cages indicate that approximately this percentage of *mexicanus* nymphs will become green under suitable conditions. As reported elsewhere, a much larger percentage of the nymphs of *Locustana pardalina* and *Locusta m. migratorioides* became green when reared in the celluloid cylinders on growing food (Faure 1932).

NYMPHS REARED IN PAINTED BOXES.—Out of the total of 70 nymphs

[2]The U. S. Entomological Commission reported that green nymphs occurred in *spretus* (first report, page 281).

reared in isolation, 22 were confined in painted boxes during their development from the first or second to the fifth instar. These cages were made of wood, and painted on their inner surfaces with ordinary commercial oil paints. After the paint had dried and the cages had been in use for some weeks, the colours were compared with and named according to the tints on the plates of Ridgway (1912) which they resembled most closely.

The colours used were very similar to those used in Africa; those which had given positive results in the African experiments were chosen, i.e., white, black, gray, yellow and brown, and in addition a few tests were made on orange and orange plus black. The treatment of the nymphs, and the method of arriving at the results were the same as those described in my recent paper (Faure 1932).

As shown in Table 1, the nymphs of *mexicanus* proved to be remarkably susceptible to the influence of the various colours of the backgrounds; the results were fully as conclusive as those obtained with *L. pardalina* and *L. m. migratorioides*.

TABLE 1. NYMPHS REARED IN PAINTED BOXES FROM THE FIRST TO FIFTH OR SECOND TO FIFTH INSTAR

Colour of box (Ridgway's nomenclature in parentheses)	Nymphs, classified according to the degree of resemblance to the colour of the background				
	None	Slight	Fair	Good	Total
White	-		1	4	5
Black			1	1	2
Gray (light mouse)	-		2	2	4
Yellow (deep chrome)		—	-	4	4
Brown (auburn)			3	2	5
Totals	-	-	7	13	20
Percentages	-	—	35	65	

In addition to the nymphs listed in Table 1, 6 others were reared in colour boxes from the third to the fifth instar; these 6 are not included in the total of 70 reared in isolation to which reference is made above. Of the six, two were noted as showing good resemblance to the background, one on gray and the other on yellow; two were described as cases of fair resemblance, one on black, and one on orange (rufous of Ridgway pl. xiv); two showed slight resemblance only, one to orange in an orange box, the other to orange only in a box painted black and orange.

Besides the 20 listed in Table 1, two others were reared from the 1st and 2nd instars, respectively, to the 5th instar in boxes painted black and orange; both of these were noted as showing fair resemblance to orange only.

A BIOMETRICAL STUDY OF THE ADULTS.—I am indebted to Mr. James A. G. Rehn of Philadelphia, the well known orthopterist, for the following summary of the structural differences between *spretus* and *mexicanus*:

"The only characters which seem to be of value in separating *spretus* from *mexicanus* are the greater size, relatively longer wings, and slightly more expanded posterior part of the pronotum of the former. Minute characters in the form of the cerci and the apex of the sub-genital plate were given by Scudder as additional features, but these appear to be individual fluctuations appearing as regularly in true *mexicanus*."

In view of the small size of the species (as compared with the African migratory locusts), and the comparatively trivial differences in the pronotum of *spretus* and *mexicanus*, I have not attempted to take measurements of the pronotum and the head. The only character which appeared to me to be readily measurable was the relative length of the wings. It need hardly be pointed out that measurements of the portion of the wing projecting beyond the tip of the abdomen are of doubtful value in view of the structural peculiarities of the abdomen

I have measured the length of the hind wing and the length of the hind femur, and have used the ratio wing/femur as an expression of the relative length of the wing The averages are also included in Tables 2 and 3, since they serve as indices of the absolute size of the specimens in the different series. For the methods of taking measurements and arriving at the results the reader is referred to my recent paper (Faure 1932). In the work on *mexicanus* the measurements were taken to the nearest quarter of a millimeter (0.25 mm.).

DESCRIPTION OF MATERIAL.—Tables 2 and 3 comprise the averages and ratios resulting from the measurements of seven series of specimens. Series i consisted of "*M. spretus*" from the United States National Museum in Washington and the Academy of Natural Sciences in Phila delphia; a number of the specimens were from the collections of C. V. Riley and S. H. Scudder; the dates varied from 1868 to 1899, but the majority were collected in the seventies of last century; the specimens came from many different localities in the region invaded by swarms.

Series ii were specimens collected by the writer at Lockhart, near Ada, Minnesota, on June 29, 1932. The grasshopper outbreak in the Red River Valley of Minnesota was mainly due to other species in 1932. but *mexicanus* was found to predominate in a few localities. At Lockhart the adults of *mexicanus* were so abundant that one could easily catch 30–40 in about a dozen sweeps with the net on a cool morning. Entomologists who saw them in the field were struck by their pale appearance and the length of their wings. The best descriptive term I

can suggest for the material of series ii is that it came from an incipient swarm. The outbreak was apparently confined to a few hundred acres, but *mexicanus* was undoubtedly present in "outbreak" numbers sufficient to attract the attention of officers concerned with the campaign of destruction that was in progress at the time.

TABLE 2. MALES: AVERAGES AND RATIOS OF BIOMETRICAL DATA. MEASUREMENTS IN MM., TO 0.25 MM.

Series	Description	Number measured	Ratio A/F wing/femur	A. Average wing length	F. Average femur length
i	"*M. spretus*" U.S.N.M and Philadelphia	31	1.897	24.78	13.06
ii	Lockhart, Minn 29. vi. 1932	51	1.710	20.50	11.99
iii	Barnesville, Minn. 28 vi. 1932	17	1.703	21.37	12.54
iv	"*M mexicanus*" U S.N M. and Philadelphia	15	1.569	18 20	11.60
v	St. Paul, Minn July 1932	34	1.656	18.77	11.34
vi	Cage-reared: crowded	75	1.585	17.10	10.79
vii	Cage-reared: isolated	37	1.536	16 82	10.95

Series iii were specimens taken at Barnesville, Minnesota, on June 28, 1932 Conditions here were similar to those at Lockhart, but *mexicanus* was not quite so dominant in numbers as at the latter place.

Series iv consisted of specimens of "*M. mexicanus*" from the collections of the United States National Museum and the Academy of Natural Sciences in Philadelphia, taken in widely scattered localities in the United States, and in many different months and years This series represents the extreme solitary phase in its short-winged form. Although the data on the pins did not indicate the density of population obtaining at the time when the specimens were collected, it is probably safe to assume that they were not taken under "outbreak" conditions.

Series v comprised specimens collected in and near Saint Paul, Minnesota, in July 1932, by Mr. H. A. Tinkham and the writer. There had been no suggestion of an outbreak within ten miles of the fields in which this material was collected, and the population was so scattered that one collector could not catch more than about 25 specimens in three hours. The insects were all collected as adults, but they were fresh, perfect specimens, and it does not seem remotely probable that they could have flown from a distance from some unreported outbreak. I consider that they must have developed as nymphs under conditions of complete isolation, and that they therefore represent the true phase *solitaria* of the species. In view of the fact that the females of *mexicanus* are very similar to those of *femur-rubrum*, I submitted all the females of this series to Mr. James A. G. Rehn who very kindly confirmed the identifications for me.

Series vi and vii consisted of the adults from the rearing experiments discussed in preceding paragraphs of this report.

Discussion of the Data.—The figures in Tables 2 and 3 show clearly that the *spretus* material exceeds all the other series in absolute size, as indicated by the averages of wing length and femur length, and in the relative length of the wings as reflected in the ratio wing/femur.

Series ii and iii show a definite variation in the direction of *spretus* in both sexes with ratios in the column A/F that are distinctly higher than those of series iv and v.

TABLE 3. FEMALES: AVERAGES AND RATIOS OF BIOMETRICAL DATA
MEASUREMENTS IN MM., TO 0.25 MM.

Series	Description	Number measured	Ratio A/F wing/femur	A. Average wing length	F. Average femur length
i	"*M. spretus*" U.S.N.M. and Philadelphia	31	1.801	25.85	14.33
ii	Lockhart, Minn. 29. vi. 1932	50	1.668	21.45	12.86
iii	Barnesville, Minn. 28. vi. 1932	16	1.669	21.03	12.60
iv	"*N. mexicanus*" U.S.N.M. and Philadelphia	13	1.526	20.03	13.13
v	St. Paul, Minn. July 1932.	21	1.607	20.32	12.64
vi	Cage-reared: crowded	91	1.509	17.13	11.35
vii	Cage-reared: isolated	16	1.500	16.84	11.22

Series iv gives the lowest ratio A/F of all the field material in both tables. A very interesting point is brought out by the figures for series iv and v, indicating that there is considerable variation in the relative wing-length of specimens of this species developing in the field under conditions of isolation. Possibly there may be geographical races of short winged forms and longer winged forms in different regions; or the variation may be due to seasonal fluctuations in temperature and rainfall acting through the moisture content of the food as suggested by the results obtained by Parker (1930) in rearing experiments.

The ratio A/F of the series v is distinctly lower than the ratios of series ii and iii in both sexes, indicating that the far greater density of population at Lockhart and Barnesville was the factor which produced the longer wings in series ii and iii.

In series vi and vii we note that the specimens reared in the cages were decidedly smaller in both sexes than the field material. In relative wing-length those reared under conditions of crowding gave a slightly higher ratio than the individuals reared in isolation, indicating a tendency to vary in the direction of *spretus*, but this ratio was still distinctly lower than that obtained from series v. The failure of the cage-crowded material to show a wing/femur ratio equal to or greater than that of the

solitaria series from the field (series iv and v) does not invalidate the main conclusions arrived at below. It should be borne in mind: 1) that the cages were exceedingly small; 2) that the crowding was experienced for one nymphal development only, and 3) that the *mexicanus* material was mixed with a preponderating number of *M. packardi* nymphs during the earlier stages If the rearing under crowded conditions were carried out with larger numbers, in larger cages, and through four or five generations, a distinct increase of relative wing length as compared with field *solitaria* material would probably be obtained.

CONCLUSION.—The observations and experiments described in the preceding paragraphs warrant the conclusion that the form considered by the United States Entomological Commission as a distinct species, and long known as *Melanoplus spretus* (Walsh) was the phase *gregaria* of *Melanoplus mexicanus* (Saussure) The name *spretus* Walsh 1866 is therefore a synonym of *mexicanus* Saussure 1861. This conclusion is based on the following facts.

1. In rearing experiments, the type of nymphal coloration described by the U. S. Entomological Commission as typical of *spretus* appeared only in cages containing crowds, whereas the nymphs reared in isolation acquired types of coloration similar to that described by the Commission for *mexicanus* (=*atlanis*).

2. Adults of *mexicanus* taken in Minnesota in June 1932 under outbreak conditions showed a strong tendency to vary in the direction of *spretus* in relative wing-length and in size.

3. There is a close similarity between the relationships of *spretus* to *mexicanus* and those obtaining between the phases *gregaria* and *solitaria* in the African species of locusts.

In view of the small amount of material that was available for the writer's experiments, and the fact that his observations covered one nymphal development only, it is desirable that further comparative studies be undertaken with large series of *mexicanus* reared under conditions of crowding and isolation. It would be particularly interesting to note the effects of rearing several successive generations of the same stocks under crowded conditions.

Another field of inquiry is offered by certain economic species which seem to occupy a position intermediate between the true solitary grasshoppers and the migratory locusts in the sense that they become exceedingly abundant and even undertake short mass-flights without actually forming swarms and migrating long distances. I refer to *Melanoplus bivittatus* (Say), *M. differentialis* (Thomas) and *Camnula pellucida* (Scudder). Fragmentary observations made in Minnesota

in 1932 suggest that the nymphs of *differentialis* may show a tendency to develop a type of coloration similar to that of the phase *gregaria* of true locusts when reared under conditions of crowding. Finally I wish to call attention to the desirability of studying the effects of crowding and isolation upon the nymphs of *Schistocerca americana* (Drury). It may prove to be the solitary phase of the migratory locust of South and Central America, *Schistocerca paranensis* (Burmeister).

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VAPO DUST—A DEVELOPMENT IN SCIENTIFIC PEST CONTROL

By William B. Parker, *Entomologist, Research Department—California Spray-Chemical Corp., 15 Shattuck Square, Berkeley, Calif.*

Vapo Dust[1] and the Vapo Dust Machine are new developments in Scientific Pest Control. By this process Phytonomic Oils,[2] alone or containing concentrated insecticidal or fungicidal materials, are diluted with air to form a fog that envelops pest-infested plants or trees in such a way as to rapidly, economically, and completely cover them with a thin and uniform film of very active material.

The application of pure oil as an insecticide is not new. Matthew Cook used kerosene in killing San Jose Scale as early as 1882 and it was later recommended by Professor J. B. Smith in 1897 as follows: "The essential points to be regarded in the application of pure kerosene are, the finest possible spray, the completest and thinnest possible coating over the entire surface, the weather conditions favoring rapid evapora-

[1]The term Vapo Dust is a registered trade mark of the California Spray-Chemical Corporation.

[2]Phytonomic oil may be defined as an oil that can be safely applied to plant foliage without causing injury. More specifically, it refers to lubricating type oils from which unsaturated hydrocarbons, sulphur, the more sensitive cyclic hydrocarbons, acids having organic nucleii, and more volatile bodies, and other chemically active bodies that would cause injury to foliage have been removed.

1 Demonstration Vapo Dust Machine used to apply oils as a winter spray on deciduous fruits. This machine will do four to six acres of orchard per hour. A thin film of oil is uniformly applied to every part of the tree.

2 Vapo Dusting Grapes for Leaf Hopper in the San Joaquin Valley, California. About fifteen of this type of machine and many smaller outfits are now in practical use.

U.S.D.A., some tests were made on the Beet Leaf Hopper (*E. tenella*). The results obtained were so good that the Spreckles Sugar Company treated a large acreage of breeding grounds. Mr. Schwing estimates that they destroyed at least four billion Beet Leaf Hoppers, which resulted in a great saving of sugar beets in 1932. The following fall a larger area of breeding grounds was treated with an estimated destruction of 90 per cent of the "Bug Population" of the San Joaquin Valley of California.

These two campaigns would not have been possible had it been necessary to use an insecticide diluted with water. It would have been impractical to haul water to spray these large isolated areas and, furthermore, a wet spray had not proved effective against this insect.

To date Vapo Dust has been successfully used for Beet Leaf Hopper, Grape Leaf Hopper, Brown Apricot Scale, Red Spider and Thrips on Prunes, Thrips on Onions, Aphis, Thrips and Leaf Miner on Field Peas. Mixed with Bordeaux or Coposil it is being tested during the dormant periods as a combined fungicide and insecticide. The Arsenicals, the Fluorine Compounds, Nicotine, Pyrethrum and other materials will be used with it later for leaf eating insects. This field offers great promise.

Attempts to destroy pests with pure oil have been made in the past, but usually with disastrous results to the plants concerned. With Mr. W. H. Volck's development of the foliage oils and the invention of the Vapo Dust Machine, it is now possible to safely apply straight phytonomic oils alone or combined with concentrated fungicides or insecticides in carrying on work in Scientific Pest Control.

FISH MEAL AS A FOOD FOR CLOTHES MOTHS

By Grace H. Griswold, *Cornell University*

Abstract

Experiments have demonstrated that fish meal is a food highly satisfactory to larvae of the webbing clothes moth Insects reared on this material went through their life cycles in a surprisingly short time. With fish meal as the only food supply, a method has been developed for rearing large numbers of clothes moths in gallon-sized cardboard cartons.

About two years ago clothes moths were found infesting fish meal in various departments at Cornell University where experimental work with fishes is being carried on. Since studies were under way at the Insectary on the food habits of the webbing clothes moth, *Tineola*

bisselliella Hum., it seemed advisable to conduct some experiments with this material. A supply of the meal was procured from the University Fish Hatchery and various tests with it were made. This food is evidently adequately supplied with all of the elements necessary for the development of the webbing clothes moth. With only fish meal as food, the insect went through its life cycle in a surprisingly short time, and the death rate was found to be very low. Twenty-five newly-hatched larvae were placed in an incubator and kept at a constant temperature of 77°F. All twenty-five larvae developed to maturity and emerged as adults within less than 60 days after the eggs had been laid. The life cycles varied from 45 to 59 days, with an average of 50.96 days.

Generally, under ordinary conditions, the webbing clothes moth does not become mature until at least three or four months after the egg is laid. Exceptional individuals may pass through their life cycles in a much shorter time, while others may require a year or more to complete their development. Since the present studies were begun, over 900 specimens have been reared to the adult stage in individual vials, with life cycles varying all the way from 54 to 780 days Even when kept at a constant temperature of about 80°F, the entire developmental period has ranged from 45 to 181 days

On none of the other foods used has the life cycle been as uniformly short as on fish meal With no other material tested has every single individual in an experiment completed its development and emerged as an adult. Fish meal, therefore, is evidently a food highly satisfactory to larvae of the webbing clothes moth

Where large numbers of these insects are used for testing various methods of control, it is often difficult to keep on hand a supply sufficiently large to meet all needs. With fish meal as the sole food supply, an efficient method for rearing clothes moths has been devised at the Cornell Insectary.

Cylindrical cardboard cartons, such as are used for packing butter and cheese, make good rearing cages. The gallon-sized carton is about 7 inches high and 6¾ inches in diameter. The cartons are inexpensive, and, since they can be stacked up on shelves, they occupy very little room.

In the center of a large square of cloth (about 22 by 22 inches) is pasted a circular piece of heavy cardboard, slightly smaller than the bottom of the carton. The cloth is placed in the container so that the cardboard rests on the bottom. A layer of fish meal, about half an inch thick, is spread evenly over the circle of cardboard. The cloth is then folded back against the sides of the carton and the cover is put on. Adults

are admitted to the container through a small opening cut in the cover. This opening is closed on the outside with a piece of cheese cloth secured by a little paste. To infest a new container it is only necessary to catch a few adults in small vials and drop them into the opening in the cover of the carton. The females have easy access to the fish meal and will lay quantities of eggs. At temperatures similar to those of an ordinary living room, adults will begin to emerge within about two months after a container has been infested.

When one wishes a supply of larvae, the carton can be opened and the square of cloth carefully lifted out In this way, the entire contents of the carton can be removed without disturbing the layer of fish meal, which rests on the circle of cardboard in the center of the cloth. Larvae will be found crawling all over the cloth and can be removed with the aid of a camel's hair brush. If the cloth is black, the white bodies of the larvae stand out clearly.

If eggs are desired, all that is necessary is to catch a few adults and place them in a vial with a piece of dark flannel. Since adults shun the light, they will be found hiding in folds of the cloth where they are easy to catch. Some, of course, will escape when the carton is opened. To obviate this, one can have a second piece of dark cloth ready and throw it over the carton as soon as the cover is removed. Adults will hide in the folds of this second cloth as well as in those of the cloth already in the carton. If the folds of the two cloths are turned back slowly and carefully, a number of adults can be caught in a few minutes.

By this method literally hundreds of clothes moths can be reared in a very small space. At the Cornell Insectary, two or three new cartons are infested each month, in order to assure an adequate supply of insects for all needs that may arise. Just how long an infestation will keep itself going, has not yet been determined. If a little fresh fish meal is occasionally added to each container, it seems probable that the various colonies will maintain themselves for a considerable period of time.

A NEW DEVELOPMENT IN THE FIXATION OF NICOTINE[1]

By WARREN MOORE, *Formerly Research Assistant, Rutgers College*

ABSTRACT

A new insoluble nicotine insecticide is prepared by heating an aqueous solution of nicotine, resorcinol and formaldehyde. A finely divided precipitate is obtained. The washed, air-dried product contains about 22% nicotine. The nicotine dissolves in water to the extent of 0.004 gm in 100 cc. It is about one-fifth as soluble as the nicotine in Nicotine Tannate. Prepared as a paste, the new material was mixed with oil and applied to apples by dipping. Its toxicity to codling moth (*C. pomonella* L) was equal to that of Nicotine Tannate. The oil caused it to stick to the apple, so that the deposit was about twice as reistsant to washing with water as was a deposit of Nicotine Tannate.

In a previous communication[2] I have compared Nicotine Tannate and Arsenate of Lead as cover sprays for codling moth, to the advantage of the former. The efficiency of Nicotine Tannate is greatly reduced by the rapid disappearance of nicotine from fruit and foliage sprayed with it.

When vessels are placed under trees, which have been sprayed with Nicotine Tannate, considerable nicotine is recoverable from the water which accumulates after rains. From dry Nicotine Tannate 0.15 to 0.20 gm of nicotine will dissolve in 1000 cc. of water. When Nicotine Tannate is made in the spray tank, some 40% of the nicotine remains unprecipitated. Nicotine Tannate is, accordingly, much more soluble in water than the arsenicals and this is believed to account in large measure for its rapid loss from sprayed trees. Its effectiveness is due to its great toxicity.

Attempts to prevent the dissolving away of Nicotine Tannate by the use of sticking and coating materials have resulted in failure. Only fish oil has given encouraging results. It was felt, therefore, that the discovery of a less soluble nicotine preparation was desirable. Such a substance was prepared, and will be described in this paper.

PREPARATION AND PROPERTIES. The product was made by heating a mixture of nicotine, resorcinol and formaldehyde to 90° C. The voluminous precipitate was filtered by suction and washed with water. A portion was air dried and readily disintegrated into an extremely light, fine powder. The air dried powder contained about 22% nicotine. On treating with water, only 0.004 grams of nicotine dissolved in each 100 cc. Under similar conditions, about 0.015–0.02 gm of nicotine per 100 cc. dissolves from Nicotine Tannate. The air dry material is very difficult to wet with water, but is easily wet by oil, contrasting with Nicotine tannate, which is a hydrophile substance. If the material is treated with a suitable substance, such as flour or milk powder, a dry product can be produced which wets readily and can be used either as a dust or a spray. The wetting agent can be mixed to advantage with the wet filter cake and the entire mass dried together.

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology. [2]Journal Economic Entomology *25*, 554–559 (1932).

TABLE 1. EFFECT OF WASHING UPON CODLING MOTH INJURY. TEN LARVAE WERE PLACED ON EACH APPLE. NUMBERS INDICATE THE NUMBER OF INJURIES OBSERVED

Series	Treatment	Before Washing	One Washing	Two Washings	Three Washings
1...........	Nicotine tannate	1	4	5	
	Nicotine tannate	1	3	7	
2...........	Nicotine tannate	1	2	4	5
	Nicotine tannate	0	0	3	8
	Nicotine tannate	1	2	4	4
	Nicotine tannate	0	3	4	6
3...........	Nicotine tannate			5	
	Nicotine tannate			2	
	Nicotine tannate			1	
	Nicotine tannate			3	
	Nicotine tannate			4	
Average..........					5.75±0.5
1...........	No. 1 oil	1	3	6	
	No. 1 oil	0	0	2	
2...........	No. 1 oil	0	2	4	3
	No. 1 oil	2	2	5	5
	No. 1 oil	0	2	2	2
	No. 1 oil	2	3	3	4
3...........	No. 1 oil			0	
	No. 1 oil			0	
	No. 1 oil			2	
	No. 1 oil			1	
	No. 1 oil			2	
Average..........					3.50±0.38
	Controls				
1...........	Nicotine tannate and oil	1	4	6	
2...........	Nicotine tannate and oil	0	2		
	Nicotine tannate and oil	0	3		
	Nicotine tannate and oil	0	5		
	Nicotine tannate and oil	1	7		
Average..........			4.2±0.52		
1...........	Oil	3	3	7	
2...........	Oil	5			
	Oil	4			
	Oil	5	7		
	Oil	3	7		
Average..........		4±0.27			
1...........	Untreated	11	6	9	
	Untreated	6	6	9	
2...........	Untreated	7	9	6	
	Untreated	4	7	7	
	Untreated	4			5
	Untreated	5			2
3...........	Untreated		4		
	Untreated		5		
Misc.......	Untreated		1		
	Untreated	5	4	7	
	Untreated	6	6	7	
	Untreated	9	8		
	Untreated	9	7		
	Untreated	8	5		
	Untreated	7	6		
	Untreated	7	5		
	Untreated		6		
Average all untreated (36).........		**6.25±0.23**			

Since the material is very insoluble in water and readily wet by oil, it seemed probable that it could be caused to adhere to foliage by the use of oil. Having been "stuck" in this way, its low solubility should prevent rapid loss of nicotine by leaching. That these suppositions are correct is indicated by laboratory tests, a description of which follows.

LABORATORY TEST WITH CODLING MOTH. The washed filter cake, described above, was ground thoroughly with a mortar and pestle to form a smooth paste, which was found to contain 63% water and 7.4% nicotine. To make the spray solution, 2 gm of the paste was dispersed in 300 cc. of water to make a mixture containing 0.05% nicotine. This will be designated as No. 1 in what follows. In some cases an oil emulsion was added at the rate of one part to 200.

Nicotine Tannate was prepared as described by me in an earlier issue of this Journal (loc cit). The spray solution contained 0.0625% nicotine. In some cases the oil emulsion was added as in mixture No. 1.

Small green apples, free from spray residue and codling moth injury, were used in the tests. A rubber band was attached to the stem of each apple. The apples were dipped 30 seconds in the solution to be tested and hung up in the laboratory to dry. A fan was sometimes used to hasten drying. When the apples were dry, each was placed in a small jar with an open top and ten active, newly hatched codling moth larvae were placed on each apple. The following day the apples were examined and the number of injuries (stings plus entries) recorded.

The apples were then soaked 30 minutes in tap water, washed under the tap for one minute, dried and tested with larvae as before. In some cases this was repeated three times In one series the apples were dried and washed twice before testing.

The observations are summarized in Table 1.

Comparing Nicotine Tannate with the New Product plus Oil, we see no significant difference before washing or after the first washing. A marked difference is evident after the second washing. This becomes very apparent when the apples are grouped according to the number of injuries. This is done in Table 2.

In the No. 1 and Oil column the average cannot be calculated directly because some of the observations have a zero value. The average is represented by the number of injuries occurring most frequently. For Nicotine Tannate this is 4 (the nearest whole number to the average). For No. 1 and Oil it is 2. We may also note that three times as many (63%) of the No. 1 and Oil treated apples show two stings or less as of the Nicotine Tannate treated apples (18%). The data indicates that

the New Product plus Oil is about 2–3 times as effective, after the second washing, as is Nicotine Tannate.

TABLE 2. PER CENT OF APPLES HAVING DIFFERENT NUMBERS OF INJURIES AFTER TREATMENT WITH NICOTINE TANNATE, OR WITH NO. 1 AND OIL, FOLLOWED BY TWO WASHINGS WITH WATER

Number of injuries	Controls No treatment		Nicotine tannate		No. 1 and oil	
0	0		0		18%	
1	2.9%	6%	9.0%	18%	9	63%
2	2.9		9.0		36	
3	0		18.0		9	
4	11.2		36.0		9	
5	16.7		18.0		9	
6	22.2		0		9	
7	22.2		9			
8	5.8					
9	13.9					
10	0					
11	2.9					
12	0					
Average	6.25±0.23		3.82±0.26		—	
No. of apples	36		11		11	
No. of insects	360		110		110	

Passing to the data on the third washing we may compare the averages, since no zero values appear. These are as follows:

Controls—no treatment 6.25±0.25 injuries per apple
Nicotine Tannate 5.75±0.5
No. 1 plus Oil 3.50±0.38

The difference between control and Nicotine Tannate is 0.50±.55. Since the probable error exceeds the difference, no difference is shown to exist. The Nicotine Tannate apples have lost their toxicity.

The difference between the control and the New Product plus Oil is 2.75±0.45. The difference is six times the probable error and, therefore, the odds that the difference is not due to random sampling are better than 1,000 to 1.

We may call this difference (2.75) the "residual toxicity," and dividing it by 6.25, the average for the controls, we get 0.44. We may say that the New Product plus Oil has retained nearly half its toxicity when Nicotine Tannate has lost all its toxicity.

This concludes the experiments on the comparison of the sticking properties of the New Product plus Oil and Nicotine Tannate. It has been demonstrated that the New Product can be "stuck" with oil. When adhesion is effected in this way it is removed by washing with water much more slowly than is Nicotine Tannate. If our belief that such washing is the major cause of loss in the field is correct, we may expect the New Product with Oil to be a much more effective insecticide than Nicotine Tannate.

THE REMOVAL OF LEAD AND ARSENIC SPRAY RESIDUES FROM APPLES[1]

By ALBERT L. WEBER and HARRY C. MCLEAN, *New Jersey Agricultural Experiment Station, New Brunswick, New Jersey*

ABSTRACT

As the result of numerous fruit washing experiments, methods have been devised to satisfactorily and economically remove lead and arsenical residues to meet the new U. S. Food and Drug Administration regulations.

Upon the announcement by the U. S. Food and Drug Administration of a tolerance for lead in foods, the fruit industry faced a very serious problem. Although successful methods for the removal of arsenic have been in use for some time, no work has been done heretofore upon the removal of lead.

Although the arsenical residue tolerance remains at .01 gr. As_2O_3 per lb. and the new lead tolerance is .014 gr. Pb. per lb., the practical effect of meeting the lead tolerance will be to lower greatly the arsenical residue. This is true because the lead and arsenic are applied to fruit in the form of acid lead arsenate which contains 2.76 parts of lead (Pb.) to 1 part arsenic (As.). However, the lead tolerance is expressed as Pb. and the arsenic tolerance is expressed as As_2O_3, making the Pb. to As_2O_3 ratio--2.09 to 1.

In view of previous experiments on and experience with removal of arsenic from apples, it was decided to use only those methods which were found successful in reducing the arsenical residue to fulfill the legal requirements regardless of the degree of difficulty of washing (1, 2).

OBJECT OF THE EXPERIMENTS. The object of these experiments was to find a method that would remove the excess lead as well as arsenic from apples known to be difficult to wash. Any substance used would necessarily have to possess the following attributes: (1) Economical, (2) non-injurious to fruit and workers, (3) effective without heating if possible, and (4) suitable for use with homemade flotation washers or dipping tanks as well as different types of commercial washers.

PLAN OF THE EXPERIMENTS. All washing tests were performed in the laboratory. However, previous experiments have indicated that these methods can be used in all types of washers.

Because of the small quantities of apples available at the time of this work, no tests in homemade and other types of commercial washers could be made.

[1]Journal series paper of the New Jersey Agricultural Experiment Station, Department of Spray Residue Investigations.

The washing method used was made to approximate as closely as possible the washing actions and conditions obtained in a homemade flotation washer. All samples of apples were in contact with the washing solution at 70° F. for 2.5 minutes, except where otherwise noted.

Results of the Experiments. The results of these experiments are contained in Table 1.

Table 1. A Comparison of the Efficiency of Various Solvents on Lead and Arsenic Residue Removal

	Residue remaining[4]							
	Stayman		Winesap		York Imperial		Rome Beauty	
Washing treatment	Pb. Grs per lb	As_2O_3 Grs. per lb.	Pb. Grs. per lb.	As_2O_3 Grs. per lb	Pb. Grs. per lb	As_2O_3 Grs. per lb.	Pb. Grs. per lb.	As_2O_3 Grs. per lb.
No treatment	.117	044	.120	.047	132	067	—	-
1.5% HCl[1]	.023	.011	.048	.013	.054	.023	.009	.002
1.5% HCl+1% "Vatsol"	.008	.001	012	.001	010	.006		--
1.5% HCl+.5% "Alkanol B"	006	.001	028	.005	.025	013	-	-
10% BW Brand Silicate[2]	.038	.009	.035	.005	--		-	--
1.0% HCl+.5% "Vatsol"[3]	.005	.001	.007	.003	-	-	—	—
1.0% HCl[3]	.020	.010	.038	.015	—	.	-	-

[1]All percentages given in this paper are on weight basis.
[2]Temperature of washing solution 110°F.
[3]Temperature of washing solution 100°F.
[4]The results given are the averages of the results obtained from several samples.

The York Imperial and Stayman apples used in obtaining the data given in Table 1 were grown in the Glassboro district of New Jersey, and the Winesap apples in Yakima district of Washington. The Stayman and York Imperial apples were sprayed alike, receiving eight cover sprays, three of which contained oil. The Winesap apples were sprayed heavily with lead arsenate also, and because of their very waxy condition, it was very difficult to remove the spray residue. All of these apples were kept in cold storage from the time of picking until used for these tests.

The Rome Beauty apples were grown in the Moorestown district of New Jersey. They were washed at the time of harvest in a flood type of commercial washer. They contained no late oil sprays but were sprayed heavily with lead arsenate.

Discussion of the Results. The results obtained from the York Imperial apples are higher than those from the Stayman apples although they were sprayed alike. This may be accounted for by the fact that the York Imperial apples had a heavy coat of natural wax at the

time of the washing tests, whereas the Stayman apples did not. The Winesap apples likewise were heavily coated with wax. This covering of wax probably accounts for the difficulty encountered in removing the lead and arsenic from the Winesap apples with most solvents.

In comparing the relative efficiencies of "Vatsol" and "Alkanol B," it is noticeable that "Vatsol" in conjunction with hydrochloric acid will reduce the lead and arsenic residue within legal requirements whether the fruit was oil sprayed or contained a heavy coat of wax or both. On the other hand, "Alkanol B" is as efficient as "Vatsol" if the apples are oil sprayed but is not sufficiently effective where the apples are coated with wax. Furthermore, the use of "Alkanol B" will not bring the apples within the legal requirements either as to the lead or as to the arsenic tolerances where the apples are covered with both oil and wax.

The use of heat allows a reduction in the quantity of acid and wetting agents Robinson (3) has stated that a brand of silicate is the only alkali that will remove the lead as efficiently as hydrochloric acid. Langlois (2) has shown that of thirty-three brands of silicate tested, the "BW Silicate" was the most efficient one for the removal of arsenic. The results in Table I show that "BW Silicate" when used at a temperature of 110° F is more effective than hydrochloric acid alone for the removal of arsenic and as effective as hydrochloric acid alone for the removal of lead. However, the "BW Silicate" does not bring the lead residue within the tolerance and is not nearly as efficient as hydrochloric acid used with wetting agents in removing either arsenic or lead.

The use of hydrochloric acid alone is sufficient to remove the lead and arsenic so that the spray residue is reduced to meet the provisions of the Federal Food and Drugs Acts of 1906, provided no late oil spray has been used or the apples do not contain a heavy coat of wax.

CONCLUSIONS. From results obtained in washing experiments it can be concluded that the new lead tolerance can be met under the following conditions: (1) with hydrochloric acid alone where no late oil sprays have been used or no heavy wax coat is present; (2) With "Vatsol" or "Alkanol B" in conjunction with hydrochloric acid where late oil sprays were used, but the fruit has not become waxy; (3) With "Vatsol" and hydrochloric acid where the fruit is heavily coated with wax and may or may not contain oil sprays.

Alkaline washes did not remove lead satisfactorily from apples used in this experiment.

The use of wetting agents with acid gives the washed fruit a clean and attractive appearance while alkaline washes leave the fruit with a dull, cloudy finish.

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Scientific Notes

Length of Adult Life of *Paratrioza cockerelli* (Sulc). It is interesting to note from the following table that the adult potato psyllid is able to survive for a considerable length of time upon various plant species upon which nymphs have not been found to develop. This ability undoubtedly contributes to the successful survival of the adult psyllids from the time potato vines and other breeding plants mature or are killed by frost, until the winter hibernation period. Again, it is of assistance in the spring, supplying a source of food until breeding hosts become available. These data are based upon a limited number of cage tests; it appears likely that the adult psyllids often survive much longer under favorable conditions.

Host plant	Days of life	Host plant	Days of life
Alfalfa	19	Pear	35
Arborvitae	44	Plum	56
Boxelder	28	Rainier Apple	20
Bridal Wreath	56	Raspberry	56
Colorado Blue Spruce	61	Red Clover	56
Currant	26	Roundleaf Mallow	20
Douglas Fir	96	Scotch Pine	93
Grape	20	Snowberry	56
Honeysuckle	17	Sugar-beet	20
Juniper	56	Tree of Heaven	56
Lilac	56		

The majority of the breeding hosts so far noted in Utah are solanaceous plants. Most of these are not available in early spring or late fall.

G. F. KNOWLTON, *Utah Agricultural Experiment Station, Logan, Utah*

Lime-Sulfur Injury Accentuated by Casein Spreader. In commercial trials with casein spreader in 1922, several cases were observed where the spreader apparently accentuated the burning of fruit and leaves with lime-sulfur spray, particularly in pear orchards. The succeeding year cooperative tests on this point were arranged with growers in Georgia, New Jersey, Connecticut, New York, Michigan, Colorado, Washington, Oregon, and California. In each test a pear orchard was given the usual spray of lead arsenate and lime-sulfur and the spreader was used only on certain rows. In eight orchards where injury resulted, it was most pronounced or was confined

entirely to the rows where the spreader was used. It was believed the injury was lime-sulfur burn and not arsenical burn, but this question apparently has remained unsettled. Three observations are here given which indicate definitely that the spreader tends to accentuate lime-sulfur injury: In 1925 a large pear orchard in southern Oregon was divided into plots which received treatments of lime-sulfur, with lead arsenate and casein spreader and without these materials, in various combinations. There resulted a considerable amount of burn which was confined entirely to the plots where the spreader was used, and it was no more pronounced with the spray of lime-sulfur and lead arsenate than with the spray of lime-sulfur only. In the late winter of 1926 an apricot orchard near San Jose, California, was sprayed with lime-sulfur, and casein spreader was used in the spray on part of the grove. The injury to twigs was very severe where the spreader was used. In the early summer of 1932, several rows of plum trees near Pomona, California, were sprayed with lime-sulfur and on a few rows casein spreader was used in the spray. Where the spreader was used the crop was nearly a total loss from spray injury, while on the remainder of the orchard the injury was much less pronounced.

In the three groves cited the severe injury was sharply delimited to the rows where the spreader was used. Prior to 1926 casein spreaders of various brands consisted of approximately 80 per cent hydrated lime and 20 per cent casein. In the last several years some spreaders have been composed of casein, soy bean flour, and hydrated lime. The latter type of spreader was used in spraying the plum orchard in 1932.

RALPH H. SMITH, *Entomologist, University of California Citrus, Experiment Station, Riverside, California*

***Otiorhynchus ligustici* L, A European Snout Beetle New to this Country.** In the latter part of April the writer received from H. L. Page, County Agent, Oswego, N. Y. several beetles which were collected from newly set raspberry plants. At first glance they were thought to be the common black vine weevil *O.* (*Brachyrhinus*) *sulcatus*. Closer examination and a careful comparison, however, showed that the specimens were markedly different in character from this well-known weevil. The beetles were taken to Dr. P. P. Babiy who, after a more thorough examination of the literature, identified them tentatively as *O. ligustici* Linn. In our desire, however, to be sure of the species we sent the specimens to Mr. L. L. Buchanan for his identification. He confirmed the conclusion of Dr. Babiy and observed, that the species had not been reported from North America heretofore.

In an attempt to obtain further information concerning this beetle Mr. Page informs me that they came from the farm of Raymond Cooper, R. D. 7, Oswego, N.Y. Although the beetles were originally collected from raspberries they did not come to the farm on these plants. Further examination by Mr. Page in the vicinity in which the beetles were first found disclosed the fact that they were evidently among the grass and weeds where they had probably lately emerged from the soil. The beetles were not abundant and one person, at least, felt fairly sure that he had seen the beetles during the previous summer.

Brehm's Tierleben, vol. 2, fourth edition, p. 502, speaks briefly of *O. ligustici* Linn as follows: It is a black gray scaled species with a keeled snout and finely knobbed, faintly striated elytra. It is a beetle which eats the buds and shoots of many different plants, and has become injurious to peaches, grapes, asparagus, beets and other growing plants. It sometimes attacks clover fields by the thousands. In southwest-

ern Russia the beetles have been observed in great numbers composed entirely of females which had the power of reproducing parthenogenetically.

GLENN W. HERRICK, *Cornell University, Ithaca, N. Y.*

Control of the Birch Leaf-Mining Sawfly. This European sawfly (*Phyllotoma nemorata* Fallen) has been seriously injuring the birch foliage over a large part of Maine since 1927. The eggs are deposited in the mesophyll of the leaf-teeth and the larvae are solitary miners until mature. They form a silk-lined hibernaculum in the mine in which they overwinter. But one generation occurs. The insect is completely parthenogenetic. The birch leaf miner, *Fenusa pumila* Klug differs in all of the foregoing points.

Native parasites are attacking this sawfly in increasing numbers and European parasites have been introduced.

The brown unsightly appearance of the leaves on ornamental trees has led to considerable spraying. Since the insect has spread westward into New York, it seems desirable to publish spraying recommendations in advance of a forthcoming bulletin. Four years of spraying work has shown that this insect can be controlled with one application of nicotine sulphate and soap or Penetrol. Nicotine sulphate 1 to 800 with soap is recommended. This has given 100 per cent kill in experimental tests and good control on large trees in the hands of commercial spraying companies. In experimental work in the field, dilutions of 1 to 1000 have given 99 to 100 per cent kill, and 1 to 1500, 98 to 100 per cent kill. These weaker dilutions have not been tested with power outfits on large trees. The time of application is very important as the larvae become highly resistant after the second instar. The egg stage is nineteen days and the eggs are killed by the spray. It is recommended that the spray be applied when the oldest mines reach a diameter of one-fourth to three-eights inch. This is from July 20 to 30 in central Maine. An application at this time or slightly later has given satisfactory control of both the sawfly and the birch skeletonizer, *Bucculatrix canadensisella* Chamb.

Preliminary work indicates that Bordeaux mixture 3–3–50 applied in central Maine June 12 to 20 and twelve days later will give fair protection.

A. E. BROWER, *Maine Forest Service*

The Effect of Low Temperature on the San Jose Scale in Georgia. Many southern peach growers believe that an unusually low temperature for the latitude of Georgia kills a large percentage of the San Jose scales on peach trees, and some even omit the dormant spray for scales if the weather is very cold. An opportunity was presented this year to determine the reduction in the percentage of live scales in an unsprayed peach orchard (A) as a result of a very low temperature. The data are given in the

	Before freeze		Freeze		After freeze		Reduction in percentage of live scales due to low temperature
Orchard	Date	Average percentage of live scales	Date	Minimum temperature	Date	Average percentage of live scales	
A	Feb. 4, '33	92.0	Feb. 9, '33	11.9°F.	Mar. 17, '33	57.2	22.3
B	Feb. 23, '32	85.5	Mar. 10, '32	18.0°F.	Apr. 25, '32	54.0	36.8
C	Feb. 23, '32	92.0	Mar. 10, '32	18.0°F.	Apr. 25, '32	59.0	35.9

accompanying table together with data on the effect of a fairly low temperature on scales in two unsprayed orchards (B and C) six miles apart in the spring of 1932.

There was a larger percentage of young scales on the trees when the freeze occurred in 1932, as there had been no cold weather before that time and reproduction had been heavy during the winter. Cold weather before the freeze in 1933 had retarded reproduction. Young scales are more susceptible to low temperature than the half-grown forms, and that accounts for the difference in the reduction of scales during the two years. The data indicate that unusually low temperatures in southern latitudes do not kill the majority of San Jose scales on peach trees.

OLIVER I. SNAPP and J. R. THOMSON, *U. S. Bureau of Entomology, Fort Valley, Ga.*
OLIVER I. SNAPP

Many Bark Beetles Destroyed by Predacious Mite. The economic value of mites as predatory agents in the control of bark beetles has never been fully realized. These minute arthropods are related to the spiders and were found by the writer in great numbers beneath the bark of ponderosa pine trees infested with the Oregon engraver beetle (*Ips oregoni* Eichh.). Other investigators have recorded mites associated with the mountain-pine beetle (*Dendroctonus monticolae* Hopk.) in western white pine, and with the Douglas-fir beetle (*D. pseudotsugae* Hopk.) in Douglas fir, but very little other information is available concerning their association with bark beetles. Owing to their microscopic size and agility, great difficulty was encountered in determining accurately the population of these creatures in infested ponderosa pine bark, but an examination of 9 square feet showed a range of from 138 to 2,265 mites per square foot.

The activities of these tiny creatures in association with *I. oregoni* were watched under various conditions, and they were observed to feed voraciously on the eggs of this bark beetle. There are also in this station records of mites feeding on eggs of *D. pseudotsugae*. As practically no information concerning the total egg mortality of bark beetles is available, it is difficult to calculate the actual reduction in the various bark-beetle broods caused by mites. However, by counting the number of normal eggs of *I. oregoni* and the number of eggs on which mites were feeding, it was learned that from 10 to 85 per cent of the eggs were devoured. This varied from 52 per cent egg mortality caused by mites in the first generation of Ips to 85 per cent mortality in the fifth generation, with from 10 to 25 per cent in the intervening generations. One other record shows the egg mortality of *D. pseudotsugae* to be 62.5 per cent of the total number laid, and no doubt this mortality is in a large part due to mites.

Four species of mites have been found in infested ponderosa pine bark, but not all of these are predacious. Those destroying the most eggs belong to the genus *Parasitus*. As they have no wings, they are forced to depend upon their host for transportation from the old brood trees to those which are newly attacked. Just prior to bark beetle emergence the mites fasten themselves to the adult beetles. On Ips they are found clinging to the concave declivity and beneath the wing covers, whereas on the *Dendroctonus* beetles, which have a convex declivity, the mites are found under the abdomen and beneath the wing covers. As many as 42 mature and immature mites were found clinging to one adult of *I. oregoni*.

Because of this means of transportation, the mites arrive at the newly-attacked trees with their host and consequently start to feed just as quickly as egg-laying

begins. The adult female mite fastens her beak in the egg and sucks the juices. As she feeds she increases in size and when all but the eggshell has been completely consumed she begins to lay eggs. These are laid in a group around her body and are held together by a sticky fluid. The greatest number of eggs found in one of these groups was 60. Only a few days are required for the incubation of these eggs, and upon hatching the young mites scatter beneath the bark in search of food.

It is possible that mites are the most important biological agent in the destruction of various species of bark beetles. The mortality in the larval stage of certain bark beetles due to all predators and parasites except mites averages between 20 and 30 per cent, whereas the mites destroy an approximate average of 50 per cent of some bark-beetle broods.

H. J. Rust, *U. S. Bureau of Entomology*

***Ptinus tectus* Boieldieu.** This peculiar little brown or "pitchy-red" beetle appears to have first been taken in California in Salinas, on September 30, 1932 by H. A. Hunt, County Agricultural Commissioner of Monterey County. The insect occurred in great numbers in stocks of fish meal. Specimens were determined by Dr. F. E. Blaisdell. In looking up the history and economic status of this new pest of stored products I find that it was first collected in Tasmania (Van Diemen) and described by Anatole Boieldieu[1] in 1856. T. H. Beare[2] states that it was first observed in a granary at Strood, England in 1901 which is the first record of its introduction into Europe. Since that time it has frequently been reported as a pest of stored products in different countries. Some of the more important published accounts are:

England—In army biscuits. J. H. Durrand and W. W. O. Beveridge, Jour. Royal Army Med. Corps, London, vol. 20, pp. 615–634, 1913.

In chocolate and cayenne pepper. J. J. Walker, Ent. Mthly. Mag., vol. 51, pp. 18–19, 1915.

In stored grains. Bur. Biol. Technology-Leeds, Bul. 2, p. 52, 1921.

In stored cacao. A. W. Knapp, Bul. Imp. Inst., London, vol. 19, pp. 189-200, 1921.

In packets of desiccated soups, waste flour, and dead insects. G. B. Walsh, Ent. Mthly. Mag., vol. 59, p. 258, 1923.

In stored hops. F. V. Theobald. Ann. Rept. Res. and Adv. Dept., S. E. Agr. College, 1926–1927, pp. 1–16, 1927.

In Cacao. J. W. Munro and W. S. Thomson. Rept. on Insect Infestation of stored cacao. London, 40 pp., 4 pls., 46 refs., 1929.

Ireland—Infesting casein and eating holes in woollen carpets. G. H. Carpenter. Econ. Proc. R. Dublin Soc., vol. 2, pp. 259–272, 1920.

Scotland—It is also listed from this country by N. H. Joy. A Practical Handbook of British Beetles, vol. 1, p. 455, 1932.

Germany—In prepared fish food and dried meats. M. F. R. Scholz. Entom. Blätter, Berlin, vol. 16, pp. 23–24, 1920.

In stored products. F. Zacher. Die Umschau, Frankfurt, M., vol. 26, 4 pp., 1922.

In cacao. F. Zacher. Verb. Deutsch. Ges. angew. Ent., vol. 5, pp. 68–69, 1926.

In poultry feeds. H. von Lengerken.

Mitt. Ges. Vorratschutz, vol. 5, pp. 21–26, 2 figs., 17 refs., Berlin, 1929. Also in Z. angew. Ent., vol. 14, pp. 450–460, 1929.

[1] Trans. Soc. Ent. France, vol. 4, p. 552, 1856.
[2] Ent. Mthly. Mag. (2), vol. 5, pp. 4–5, 1904.

In paprika. H. von Lengerken. Z. angew. Ent., vol. 15, pp. 639, 1929.
Finland—J. Salberg. Meddel Soc. Fauna Flora fennica, Håft 40, pp. 12–15, 1914.

Other species in the family Ptinidae with similar habits are the cosmopolitan *Ptinus fur* Linn., which is perhaps the most widely distributed, numerous, and destructive member; *Trigonogenius globulus* Sol., *Gibbium psylloides* (Czemp), and the more restricted *Niptus crenatus* Fab., *N. hololeucus* Falderm.; *Ptinus brunneus* Dufts.; *P. villiger* (Reit.); *P. raptor* Sturm, and *P. lichenum* Marsh.

This insect may have been introduced into other parts of this country and has been confused with some of the above.

E. O. Essig

A Laboratory Method for Determining Approximately the Evaporation of Petroleum Spray Oils Under Field Conditions. The method used for determining the volatility of the various grades of petroleum oils depends upon the use for which the oil is intended. For spray oils of the lubricating type the Bureau of Chemistry and Soils uses a method in which 20 grams of oil are weighed into a Petri dish or an evaporating dish having a diameter of 3¼ inches; the dish and contents are placed in an electric oven, heated at a temperature of 110° C, for 4 hours, cooled in a desiccator and finally reweighed, the loss in weight being recorded as the percentage of volatile oil. In making tests at this laboratory on oils for emulsions to be used against scale insects, it was found that while the pure oils conformed to the manufacturer's specification with regard to Saybolt viscosity and unsulfonatable residue, the volatilities determined by this method were by no means in accord with the manufacturer's specifications. The discrepancies were due to the fact that the manufacturer had used a different method.

The method employed in the petroleum industry, known as the A.S.T.M. D6–27 (cf. determination of loss on heating, Institution of Petroleum Technologists Standard Method of Testing Petroleum and Its Products, pp. 102-105, 2nd ed. (1929), W. Speaight and Sons, Ltd., London) differs to a considerable degree from the method of the Bureau of Chemistry and Soils. For example, the A.S.T.M. D6–27 specifies that 50 grams of oil be weighed out and subjected to a temperature of 163° C. for a period of 5 hours. The samples are placed upon a shelf in an oven of specified dimensions. The shelf revolves at the rate of 5 to 6 revolutions per minute. Holde also discusses a number of other methods (D. Holde, The Examination of Hydrocarbon Oils, and of Saponifiable Fats and Waxes. Authorized translation from German. 5 ed. by E. Mueller, Eng. ed. 2, pp. 181–184, John Wiley and Sons, Inc., New York (1922)) applicable to the testing of engine oils.

Most methods for determining volatility are devised primarily to ascertain how an oil will stand up when it is used as a lubricant in steam and internal combustion engines and subjected to the high temperatures and pressures occurring in the cylinders. In combating scale insects the conditions are entirely different. When applied to plants and insects in the form of dilute emulsions, the oil spreads in a comparatively thin film over wide areas. The film covers the scales and is retained on the leaves and twigs for weeks. Evaporation usually occurs gradually and at a temperature which is no higher than outdoor temperatures.

A procedure which approximates the conditions of evaporation occurring on plant surfaces has been tentatively adopted at this laboratory. It is a modification of a method given by Scott (W. W. Scott, Standard Methods of Chemical Analysis, 4th ed., Vol. II, p. 1117, (1925), D. Van Nostrand Co., New York) which was originally

intended for estimating the evaporation of spindle oils. An annular disc of filter paper (1⅝ inches outside diameter, with a center hole of ⅝ inch diameter), which has previously been dried in an electric oven at 100° F. for a period of several days is placed upon a plain glass 2 inches square, and weighed to tenths of a milligram, and about 0.2 gram of oil is dropped on the paper from a small pipette. The glass, paper, and oil are then accurately weighed and placed in an oven, the temperature of which is adjusted at 100° F. (37.8° C.) for 24 hours. After the glass, etc., are reweighed, the percentage of loss due to evaporation is recorded.

The advantage of the modified Scott method is that evaporation of a small quantity of oil spread over a relatively large surface takes place over a long period of time at a convenient constant temperature only slightly above atmospheric. The rate of evaporation may be affected if grades of filter paper with varying porosity are used; however, with a standard paper this objectionable feature can be obviated.

The data below show the volatility of eleven blends of oils determined by the method of the Bureau of Chemistry and Soils, and the method proposed, and of two oils determined by the A.S.T.M. D6-27 method. The samples were obtained by mixing two pure oils known as "White Rose" and "L-1778," respectively in the proportions shown.

Sample No.	Blend of Oils*	Evaporation as determined by diff. methods A.S.T.M.	Bur. chemistry	Proposed
		%	%	%
1.	100:0	0.9	0.3	1 4
2.	90:10		0.3	1.4
3.	80:20		0.4	1.5
4.	70:30		0 7	1.5
5.	60:40		1.1	1.8
6.	50:50		0.5	1.4
7.	40:60		1.0	1.5
8.	30:70		1.3	1.6
9.	20:80		0.9	1.7
10.	10:90		1.4	1.8
11.	0:100	1.0	1.7	1.6

*White Rose: L-1778

The data suggest that "volatility" is an arbitrary term depending upon the method of determination. Apparently a different kind of evaporation occurs under the conditions of the proposed method as the variation from sample to sample is not great. Many other corroborative figures have been derived from tests. For all spray oils tested which were of specifications acceptable to manufacturers and growers, the evaporation rates range from about 1 to 2 per cent. One manufacturer claimed a volatility of 8.6 per cent for an oil known as "Extra White Rose"; when tested by this method it showed an evaporation of only 1.6 per cent. It is thought that for oils which come strictly within the lubricating class the volatility factor in spray work is relatively unimportant provided only 1 or 2 per cent evaporates during the test.

De Ong (Specifications for Petroleum Oils to be Used on Plants, Jour. Econ. Ent., Vol. 21, No. 5, pp. 698–699, October 1928) has suggested a method similar to the proposed method in which the oil is spread out upon asbestos paper. However, he uses temperatures between 50 and 100° C. and obtains a distillation curve rather than a definite evaporation figure under a standard set of conditions.

L. H. Dawsey, *Assistant Chemist, Insecticide Division, Bureau of Chemistry and Soils, New Orleans, La.*

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1933

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A A A S Winter meetings 1933 34 Boston, 1934-35 Pittsburgh, Summer meetings 1933 Chicago 1934 San Francisco

Occasionally a question arises as to the advantages of membership in the American Association of Economic Entomologists The general aspects were summarized in the preceding issue, and at present we are concerned with a more restricted phase. The Association made possible the publication of this Journal and, practically speaking, it certainly could not have attained its present size and influence throughout the world without the backing of the Association A brief comparison between subscription prices for the Journal and those for five other similar publications indicate that these latter, were they to print an equivalent number of pages, would cost nearly $8 00 each, whereas the subscription price of the Journal is but $3 50, and for members of the Association only $2 50. Granting that the Journal is worth its nominal subscription price to non-members, the actual membership fee in the Association would be but fifty cents. In other words, members of the American Association are paying fifty cents for the support of a National organization, and in doing this, they are also providing a very important though not necessarily perfect medium for the publication of scientific papers. In the earlier days, the Proceedings of the Association were published by the then Federal Division of Entomology, they appearing some nine months after the meetings. This should be contrasted with the Journal publishing the Proceedings, sometimes a considerable proportion of them, within three months after the meeting is held.

Furthermore, it is well to bear in mind the fact that opportunities for publication through National and State agencies are much more limited than in those early days, and judging from the developments of the last few months, they are likely to be restricted to a considerably greater extent. The JOURNAL OF ECONOMIC ENTOMOLOGY is the one general medium for the publication of economic papers in America. Its embarrassments are due largely to the great demands for its facilities. It is the agency which distributes throughout the world somewhat promptly, occasionally very promptly, the results of investigations in economic entomology. It is suggested that the relatively few who question the advantages of membership in the Association give careful consideration to the above and also attempt to picture the situation were we to revert, an extremely unlikely eventuality, to the conditions of earlier days. The experience of the JOURNAL has demonstrated the advantage of one well supported National serial, and while for a time our publication facilities may be somewhat inadequate, the solution is not to be found in the establishment of other agencies, but in the strengthening of the one which has already abundantly justified its existence.

This is a period of readjustment No sensible person can deny the need for economy. It is probable that the peak of official entomological work has been passed for a time, at least We may expect adjustments, possibly painful adjustments, and these may extend over a series of years. They may force a number of entomologists to look for other opportunities, although there is no question as to the fundamental value of research. We must face the fact that governmental agencies may not find themselves at liberty to invest to the same degree as formerly in this type of activity. We have departments of Zoology and Entomology in some of the larger institutions, and it is quite possible that in others not directly interested in agriculture, entomology might well be made a more prominent part of the course. The medical field is an inviting one to entomologists. Our larger medical colleges, state health departments, health officers in larger cities and the larger hospital organizations could all profit greatly by expert entomological knowledge applied to their special needs, and in some cases this has been made available. The more practical applications of entomology along agricultural lines are also worthy of consideration by entomologists. The inspection services of the various States need the best information available in regard to the constantly arising new problems and the numerous county agents throughout the country find insect troubles among their more important problems. The Superintendents of the larger farms and estates, large landscape companies, and the larger State, county and

1911. "His appointment was recommended to carry on an investigation of the grape phylloxera, including the collection of data on the distribution and injury of the insect, the variation in injury to different varieties of Vinifera grapes, and other problems connected with the behavior of this insect in vineyards" He spent much of the period from 1911 to 1917 in charge of a laboratory at Walnut Creek, California, where he was for a time associated with W M. Davidson of the same Bureau.

The results of his extensive work on the biology of the grape phylloxera during this period were published jointly with Davidson.[2]

The period from 1917 to 1919 was largely spent in the San Joaquin Valley with headquarters at Fresno. In cooperation with M. H. Lapham, of the Bureau of Chemistry and Soils, a comprehensive study was made of the grape phylloxera in relation to types of soil, an investigation which was made after he became a member of the State Department of Agriculture, the results of which were published jointly by Nougaret and Lapham[3] During his stay in Fresno he conducted some investigations on the use of sulfur fumes for the control of the grape mealybug and other insect pests of grapevines, the results of which were published in 1918 1920[4] He also did some work on the Mediterranean fig scale

On August 31, 1919, he resigned from the Bureau of Entomology to accept a position as Viticulturist in Charge of the Office of Viticulture, California State Department of Agriculture with headquarters at Sacramento, where he remained until January 15, 1927. During this period he traveled extensively and rendered services in all phases of viticulture throughout the state. Full credit should be accorded him for the services which he rendered to the grape growers in perfecting methods used in determining grape maturity and in the standardization of this important product.

In 1927 he accepted the position of viticulturist of the Fontana Farms, Fontana, California, and remained there until he signed a two-year contract, plus a two-year option with the Turkish Government in 1931. He went to Turkey on the recommendations of W. A. Taylor, Chief of the Bureau of Plant Industry, U. S. Department of Agriculture, to

[2]Davidson, W. M., and Nougaret, R. L. The grape phylloxera in California, U. S. Dept. Agr., Bul. 903, Prof. Paper, 128 pp., 10 figs., 10 pls., April 22, 1921.

[3]A study of phylloxera infestation in California as related to types of soils. U. S. Dept. Agr., Tech. Bul. 20, 38 pp., 2 figs., 1 pl., 1 col. map, February, 1928.

[4]Grape mealybug, Mthly. Bul., Cal. State Dept. Agr., vol. 7, pp. 511-514, figs. 67-69, 1918.

The achemon sphinx moth, Ibid., vol. 8, pp. 560-584, figs. 146-162, 1919.

Sulphur fumigation, Ibid., vol 9, pp. 26-31, 83-85, figs. 24-25, 1920.

A termite pest of vineyards, Ibid., vol. 9, pp. 327-330, figs. 89-91, 1920.

reorganize and assist the raisin industry there, and although he was greatly interested in and pleased with the success and progress of the work, he found the task a most difficult one due to the many problems involved in changing, not only the ancient methods of viticulture, but also in modernizing and harmonizing the ideas of growers and packers.[5] His difficulties were greatly increased by the serious financial crisis in Turkey which permitted only the strictest economy and resulted in the failure to adequately support the plans as agreed upon by the government.

According to his own word he organized the Institute of Viticulture (Bagcilik Enstitusu) at Bournabatt -a suburb six miles from Izmir. The Government also has a small Agricultural College and a Laboratory at the same place. The Institute, however, never became a realization. The difficulties of securing adequate scientific apparatus from foreign countries had not been overcome before his death. That he succeeded in improving the quality of raisins in Turkey during this brief interim is shown by the fact that his exhibit at the Chamber of Commerce scored 10 points out of the possible 11 points for perfect

He was certainly a man of high ideals and lived accordingly. What emoluments were denied him in life over there were more than lavished upon him in death. According to word from the American Consul: "The Turkish Government gave him an official burial President Kamel Pasha sent a representative; the Director of Police and four aids; the Governor; the President, professors and students of the International College; the American Colony; prominent Turkish families; the Consul and Vice-Consul all attended the funeral. So he rests forever in a foreign soil and his name is added to the long lists of American Scientists who have given their lives for the benefit of humanity.

In addition to the papers already listed, the following appeared later:

Report of the Viticultural Service, Calif State Dept. Agr, vol. 20, pp. 487-501, 7 figs., 1920, vol 11, pp 872 874, 1922; vol. 12, pp. 366 369, 1923; vol. 14, pp. 198-201, 1925.

A proposed treatment for frosted grapevines, Ibid., vol. 10, pp. 345 358, figs. 58-69, 1921.

The rootknot on grape, Ibid., vol. 12, pp 139 150, figs. 61 64.

E. O. Essig

[5]Viticulture in Asia Minor is well described in an article prepared by Mr. Nougaret shortly before his death. This article entitled: The Smyrna Raisin Industry appeared in *The California Grower*, vol. 5, no. 3, pp. 12 13, March, 1933, and is apparently his last contribution.

FRED E. BROOKS

Fred E. Brooks, an active member of long standing in the American Association of Economic Entomologists and charter member of the American Entomological Society, died following several years of ill health which culminated in a heart attack on March 9, 1933 in his home at French Creek, West Virginia He was born at French Creek, W. Va., on June 8, 1868. He attended the common schools of West Virginia and his further excellent education was received due to his own untiring efforts in reading and observation He had no college degrees but his grasp of problems, both general and specific, would put to shame many of us who hold the Doctorate. In 1896 he married Miss Grace Coburn, who with two children, Maurice Brooks and Dorothy Brooks, survive him. In early life he was a fruit grower and his personal struggles with insect problems and his success in working out practical controls led him into entomology. In 1902 he was employed by the West Virginia Agricultural Experiment Station, first as Assistant and later as Associate Entomologist, which latter position he retained till 1911. While with the West Virginia Station he conducted extensive work with grape insects and small mammals, this work being recorded in numerous West Virginia bulletins and popular articles published during this period. In 1911 he became affiliated with the Bureau of Entomology as Associate Entomologist. He was in charge of Deciduous Fruit Insect Investigations for the Appalachian Region with headquarters at French Creek, W. Va. Due to ill health he resigned from the Bureau in 1928. His best known work was with the round-headed apple-tree borer and other wood-boring insects. In addition to this he also conducted extensive research with various nut insects, especially the weevils attacking chestnut, the codling moth, the walnut husk maggot, and others Most of his research work is published in bulletins of the U. S. Dept. of Agriculture. In addition to entomology he was also keenly interested in nature generally and published many papers covering his observations in journals, such as *Nature*, *Country Life in America*, *Rural New Yorker*, and numerous others. As an observer of natural phenomena he was without a peer and it was in this way that he made his most notable contributions. In his passing, entomology loses a diligent and successful worker; the State, a conscientious and active citizen; and his friends, a friend indeed.

C. R. CUTRIGHT

Current Notes

Dr. W. E. van Steenburgh, Entomological Branch, reports excellent results in breeding *Trichogramma* in killed *Ephestia* eggs.

Mr. G Wishart, Entomological Branch, notes that more than 25,000 adults of the corn borer parasite, *Macrocentrus gifuensis*, were liberated in infested areas in 1932.

A new incubator, built especially for rearing the corn borer parasite *Inareolata punctoria* was completed and installed in the Belleville Parasite Laboratory in Ontario by the end of February.

Mr. U. C. Loftin, senior entomologist, cotton insect investigations, U. S. Bureau of Entomology, recently returned to Washington, after having spent nearly a week in Puerto Rico making a survey of cotton conditions and the status of the pink boll worm in its relation to native hosts.

The reported drastic reductions and reorganization of the Federal Government led President W. E. Hinds to appoint a committee representing the Association and consisting of Messrs. Britton, Cory, Felt, Houser and Phillips (Chairman) to go to Washington and do whatever might be possible to conserve the essential features of the entomological investigations and services of both Federal and State agencies.

Mr. R. E. Balch, Entomological Branch, attended the meetings of the Pulp and Paper Association and the Canadian Society of Forest Engineers, in Montreal, January 26 and 27. A continuation of his study of the effects of recent defoliation by the birch skeletonizer, on birch, in New Brunswick, confirms the conclusion in last year's investigation that the birch stands have been perceptibly retarded in growth by this injury.

Dr. H. L. Parker of the U. S. Corn Borer Parasite Laboratory, Hyeres, France, and Mr. D. W. Jones of the U. S. Parasite Laboratory, Arlington, Mass., visited the head office, Entomological Branch, at Ottawa, on March 3, and addressed the members of the Entomologists' Group, of the Professional Institute, on their work in Europe and the United States. Before going to Ottawa they spent several days at Belleville with the officers of the parasite laboratory.

During the latter part of January, a shipment of more than 3300 parasitized overwintered larvae of the spruce sawfly, *Diprion polytomum*, was received at the Belleville Parasite Laboratory in Ontario, from the Farnham House Laboratory, England. An additional 6,000 larvae of *Cephus pygmaeus* parasitized by *Collyria calcitrator* were also received from this source. In addition, a shipment of pupae of Leucopis, a predator of balsam and pine Chermes, together with material containing larvae and pupae of another predator of these bark lice, was received during the period.

On the evening of April 7, 1933, a meeting was held of the entomological Society of Puerto Rico, in one of the laboratories of the School of Tropical Medicine. Officers for the ensuing year were elected. Dr. G. N. Wolcott presented a paper on "A Year's Experience with the Cottony Cushion Scale in Puerto Rico," which is to be published in the July, 1933 number of the Journal, Dept. Agr. Puerto Rico. The main speaker for the evening was Dr. W. A. Hoffman, who gave a demonstration of the trematode parasite of snails and man which causes the bilhartzia disease. The distribution of the parasite in the New World, and especially in Puerto Rico, methods of infection,

treatment and control were discussed. Dr. Hoffman showed living cercariae and ova under the microscope, and demonstrated the most recently devised methods of concentrating the parasites and testing for their presence. At present, the most important project being conducted by the Society is sponsoring the publication of Dr. Wolcott's "An Economic Entomology of the West Indies," which is now being printed.

Horticultural Inspection Notes

Transit inspection activities at St. Paul, Omaha, Council Bluffs, Portland, and Seattle, were discontinued for the season on May 15.

The next meeting of the Western Plant Quarantine Board will be held in Salt Lake City, Utah, on June 12 to 14.

The State Plant Board of Arkansas on March 16 canceled the rule relating to apple blotch which applied to shipments of apple seedlings originating in Kansas.

A quarantine proclamation (No. 80) relating to the red date scale (*Phoenicococcus marlatti*) was issued by the Texas State Department of Agriculture, effective on April 20, requiring a permit for the introduction of date palms or ornamental palms or offshoots, from Arizona, California, and New Mexico.

Field inspections of the environs of pine-growing nurseries whose proprietors have applied for Federal pine-shipping permits for the coming year are now being made by Messrs. R. A. Sheals, J. M. Corliss, and C. R. Stillinger of the Bureau of Plant Quarantine, in cooperation with Messrs. H. N. Putnam, L. W. Hodgkins, and R. G. Pierce, of the Bureau of Plant Industry, and the plant quarantine officers of the various States.

The Oregon State Department of Agriculture on April 22 reissued the quarantine pertaining to the vegetable weevil by reducing very materially the long list of plants heretofore designated as hosts of the weevil; and on April 25 reissued the quarantine pertaining to the potato tuber moth and the rootknot nematode. The latter pest is not now involved in the certification of potatoes under this quarantine.

Mr. G. L. Bond, Inspector of the State Plant Board of Mississippi, formerly located at Laurel, Mississippi, is now at Iowa State College where he will receive the Master of Science degree in entomology in June. On returning to duty, he will be stationed at Durant, Mississippi, temporarily relieving Mr. D. W. Grimes, who will secure his Master of Science degree in entomology during the summer quarter at Ohio State University.

Recent court decisions of interest to plant quarantine officers include a decree by the United States District Court for the District of Nebraska upholding the State cedar rust law, and an opinion by the United States District Court for the Northern District of New York, upholding a New York State law and regulation relating to cattle certification. Mimeographed synopses of these decisions have been prepared by the Bureau of Plant Quarantine, and copies were sent to the various plant quarantine officers on April 20.

According to a railway circular, the State of Michigan on March 15 lifted its quarantines relating to the chestnut blight and to the tall barberries and Mahonias;

and the State of Louisiana issued rules effective on December 1, 1932, requiring that shipments of certified seed Irish potatoes must be accompanied by the certificate and prohibiting the shipping of such certified potatoes in bulk. The railway circular also reports amendments to Texas proclamations 78 and 79, permitting the entry, under such amendments, of properly labeled shipments of avocados into north Texas and of boxed citrus fruits into two additional counties in the non-citrus area.

Changes in the European corn borer quarantine situation include the establishing of new or amended orders on the part of Indiana, Idaho, and Illinois. The Indiana quarantine, effective on May 12, relates to the two-generation strain of the borer, provides for acceptance of certain products under certification, and places no restrictions during the period from January 1 to June 1 on green corn on the cob and young floral plants. The Idaho quarantine issued February 15, 1933, provides for acceptance of the products when certified and for ears of seed corn for exhibition purposes when subject to heat. This quarantine includes Wisconsin and Virginia among the list of States designated as infested. The principal changes in the Illinois quarantine of May 1 include the acceptance without restriction, during certain portions of the year, of green corn on the cob and also of chrysanthemums, asters, and dahlias without the previous year's stems; the removal of the provision for acceptance of seed corn on the cob for exhibition purposes when subjected to heat; and removal of the following from the list of restricted articles: oat and rye straw, celery, zinnia, hollyhock, and cosmos.

The recent revision of the Postal Laws and Regulations provides for an alternative procedure for expediting and simplifying the handling of plant shipments for terminal inspection by State inspectors. Heretofore the destination postmaster has been required to send the plants, at the addressee's expense, to a designated terminal inspection point for examination and return. This involved considerable delay and often resulted in damage to the plants. Many State quarantine officers have accordingly asked for authority to make the inspection while the package is en route and before it is delivered to the destination post office. Accordingly the present regulations provide that packages may be addressed to the addressee *in care of the State plant inspector at the proper inspection point.* The plants are inspected and the parcel is then forwarded by the inspector to the addressee, the forwarding postage being collected from the latter. It is necessary, however, for the shipper to guarantee such forwarding postage. The plant quarantine officers of one or two States are reported to have proposed this arrangement to the principal shippers who send nursery stock and other plants into their State. If plant quarantine officers of other States which have adopted the terminal inspection plan wish to work out such an arrangement, information as to its operation may be secured from the Bureau of Plant Quarantine.

The annual meeting of the National Plant Board was held at St. Louis, Mo. February 28, 1933. Seven of the eight members comprising the Board were present. Progress was reported in the preparation of a set of Principles of Pest Eradication. These are to be fundamentally similar to the Principles of Plant Quarantine approved by the regional plant boards and drawn by the National Plant Board two years ago. The desirability of uniformity in State quarantines concerning the phony disease of peach trees was thoroughly discussed. A motion was adopted "That the Board recommend to States who wish to adopt a quarantine re phony disease of peach trees, that such States accept stock from a nursery where no phony disease has been found by an authorized inspector within a mile from the nursery, or in lieu of that, all peach

nursery stock must be inspected by an authorized inspector tree by tree and certified as free of the peach root borer. Infected phony trees within a mile must be destroyed, as must also all borer infested nursery stock. The restricted articles shall be the same as those of the former Federal quarantine." Federal certification of plants and plant products to meet the requirements of State quarantines was approved by the Board. Under these conditions standards of inspection would be maintained by State and Federal governments which would be acceptable to both the sending and receiving States. Present at the meeting were Chairman W. C. O'Kane, Vice Chairman G. A. Dean, Secretary R. W. Leiby; members T. F. Adams, A. G. Ruggles, M. S. Yeomans; also Geo. M. List representing the Western Plant Board. Visitors included Lee A. Strong, S. A. Rohwer, L. H. Worthley and K. C. Sullivan. Members of the National Board also attended the meeting of the Central Plant Board on the following day.

At the meeting of the Central Plant Board held at St. Louis on March 1, H. B. Hungerford of Kansas was elected as President; P. T. Ulman of Indiana, as Secretary, and K. C. Sullivan of Missouri, as representative on the National Plant Board, with G. A. Dean, whose term has not expired. Resolutions were adopted recommending against the imposition of State quarantines except in emergencies, especially while the present serious economic conditions prevail. The Board also recommended that if possible the word "quarantine" be eliminated as a term to designate regulatory measures designed to prohibit or otherwise regulate interstate plant movement; that the requirements relating to fees and bonds be simplified or eliminated, and that where Federal quarantines are discontinued the Bureau of Plant Quarantine and the National Plant Board devise methods which will permit interstate movement of pest-free plant materials. Other subjects presented included a talk by Lee A. Strong, Chief of the Bureau of Plant Quarantine, on developments in quarantines during the past year; also a general discussion on closer cooperation between the States and the Federal government. It was agreed that if the States having phony disease infections would incorporate into their inspection requirements the recommendations of the National Plant Board with regard to that disease, the members of the Central Plant Board would not impose quarantines on nursery stock shipments from infected States. It was further recommended that the European corn borer quarantine restrictions on host plants of the two-generation strain be limited to the two-generation area in case Indiana, Ohio, Michigan, and other States in the one-generation area promulgated quarantines against the two-generation area. The next meeting will be held early in March, 1934, at Lafayette, Ind.

JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Vol. 26 AUGUST, 1933 No. 4

A PROGRESS REPORT ON SOME INSECTICIDES USED AGAINST THE EUROPEAN CORN BORER

By G. A. Ficht, *Purdue University Agricultural Experiment Station*

Abstract

This progress report offers some data relative to the reductions in the European corn borer (*Pyrausta nubilalis* Hubn.) populations resulting from the application of some common insecticides to corn.

Certain insecticides have been used on corn to determine their possible value in reducing populations of the European corn borer, *Pyrausta nubilalis* Hubn. and to obtain some information on the practicability of such treatments in reducing infestations and losses. The experiments have extended over a period of five years and have aimed at the testing of some of the insecticides in common use. During this period, notable differences have existed in the climatic conditions, in the growth conditions of corn, in the population levels of the treated areas and in the behavior of the borer. The characteristically spotted condition of the infestation and population in the fields used for treatment has also been a factor in producing variations in control or reduction figures. Hence, results have from year to year been inconsistent and variable in reference to some materials.

Climatic Conditions

The 1930 season, in particular, was abnormally hot and dry. These drought conditions have, in some instances, increased the larval reductions and injuries to corn resulting from the application of some materials which have not since produced equivalent results.

The rapid growth of the corn at the time the eggs are being laid and are hatching in the field has rendered it difficult, except by frequent application, to keep the plants covered with any material. Since a large part of the eggs are laid and a large part of the newly hatched larvae establish themselves on the new growth, it appears as though

the problem of supplying complete coverage could only be accomplished by frequent application. This was not so true during the 1930 season as the lack of rain during the period of treatment was conducive to good sticking. Also, the relatively slow rate of growth of the corn resulting from the drought conditions allowed for more complete coverage than was possible during the other seasons of study.

Population Levels

Average populations as determined in the untreated or check areas in the fields used for treatment have varied greatly during the five-year period. The lowest population occurred in 1930 when an average of 30 borers per 100 plants existed in the corn used for treatment and the highest population was an average of 520 larvae per 100 plants in the field used in 1928. The population in 1929 was 363 larvae per 100 plants, in 1931 an average of 219 borers per 100 plants and in 1932 an average of 218 borers per 100 plants occurred in the corn in these check areas.

Methods of Treatment

Each plot of corn has been given from one to four applications. The same general plan of timing applications has been used during the five years. When only one application was used, this was put on at or about the time the maximum number of eggs were hatching in the field or at approximately five days following maximum oviposition. When two applications were used, the application at the hatching peak was made and was followed by another in from five to seven days. When the corn received three treatments, an additional one was put on at approximately three days prior to the time when maximum oviposition was anticipated. In 1928 a fourth application was made just prior to the conclusion of egg laying.

Because of the abnormal trend of the 1932 egg deposition only two applications of any material were made. Maximum egg laying occurred on July 1 and the first application was made on July 5. Moth activity almost ceased following the maximum or peak of oviposition but the moths again became active and a second peak in egg laying occurred on July 9. The second application was made on July 11 and 12.

Spray applications were made in 1928 and 1929 with compressed air hand sprayers and during the remaining three years with a single cylinder spray pump operated by hand at a pressure of approximately 175 pounds. Dust applications were made with a bellows type hand

duster in 1928 and 1929 and with a rotary type hand duster during the remaining seasons.

Spray plots were approximately one-fortieth acre in extent and consisted of five rows sixty feet long. The dust plots were of the same dimensions in all years except 1931 when plots of one-tenth acre were used. The results presented here were obtained on a local strain of yellow dent corn. The larval reductions secured by these treatments were slightly greater than have resulted from equivalent applications of the same insecticides to sweet corn in the one instance in 1931 when both types of corn were given comparable treatment with a relatively few insecticides.

The number of plants dissected in each of the treated and check plots has varied with the population. The lowest number was 50 and the highest 100.

FLUOSILICATES.—Barium fluosilicate was used in 1930 at the rate of 4 pounds to 100 gallons of water. Very severe injury resulted from the first two applications and a contemplated third application was withheld. The characteristic fluorine bleaching was present on all parts of the plants touched by the spray and the premature death of those leaves receiving two applications resulted. The yield' was greatly reduced. In the other trials with this material it was used at half of this strength (Table 1) and produced satisfactory larval re-

TABLE 1. LARVAL REDUCTIONS RESULTING FROM APPLICATIONS OF BARIUM FLUOSILICATE, CALCIUM FLUOSILICATE AND COMBINATIONS

Material	Concentration	Year	Time and No. of applications	No. of trials	Per cent larval reduction
Barium fluosilicate[1]	2 lbs.—100 gals.	1931	July 2, 7, 13	3	85.6
Barium fluosilicate[1]	2 lbs.—100 gals.	1932	July 5, 11	3	54.3
Barium fluosilicate[1]	2 lbs.—100 gals.				
White summer oil[3]	2 qts.—100 gals.	1932	July 5, 11	3	71.9
Barium fluosilicate[1]	2 lbs.—100 gals.				
Fish oil	2 qts.—100 gals.	1932	July 5, 11	3	56.2
Barium fluosilicate[1]	20 per cent				
Talc	80 per cent	1931	July 2, 7, 14	4	57.0
Barium fluosilicate[1]	20 per cent				
Talc	76 per cent				
Neutral white oil	4 per cent	1931	July 2, 7, 14	4	65.4
Barium fluosilicate[1]	20 per cent				
Talc	76 per cent				
Neutral white oil	4 per cent	1932	July 5, 11	3	60.6
Calcium fluosilicate[2]	10 lbs.—100 gals.	1932	July 5, 11	3	73.7
Calcium fluosilicate[2]	50 per cent				
Talc	50 per cent	1932	July 5, 11	3	55.62

[1]Proprietary compound: 80% barium fluosilicate, 20% inert material.
[2]Proprietary compound: 15% calcium fluosilicate, 85% inert material.
[3]Proprietary emulsion containing 65% actual oil; viscosity 80–85 sec., Saybolt at 100 degrees F. Used at the rate of 2 qts. actual oil per 100 gals.

ductions. At the rate of 2 pounds to 100 gallons some bleaching of the leaves has occurred where two and three applications have accumulated but yields have apparently not been depressed. This typical injury has been present in the dusted plots to a limited and much lesser extent and yield reductions, if present, have been small.

Calcium fluosilicate has shown less tendency to injure the plants than barium in the one year in which it has been tested. It appears to be equally toxic to the borers and is the most promising material used to date.

In preliminary experiments with sodium fluosilicate severe injuries have resulted from its application in dust form at the rate of 20 per cent of the fluosilicate and 80 per cent talc.

Arsenicals.—Acid lead arsenate has been one of the best materials used when considered from the point of view of injury to the plants and has produced no reductions in yield. The rate of kill has not been high when used by itself (Table 2) but when combined with oil emulsions quite satisfactory larval reductions have resulted from three applications of the combination. In 1931, 62.8 per cent of the borers were apparently killed with the oil and lead combinations as compared to 49.7 per cent in the case of the same oil used at the same concentration but lacking the lead arsenate. When combined with summer oil emulsion three and two applications used in 1931 and 1932 have not reduced yields.

Table 2. Larval Reductions Resulting from the Use of Arsenicals and Arsenical Combinations

Material	Concentration	Year	Time and No. of application	No. of trials	Per cent larval reduction
Acid lead arsenate	4 lbs.—100 gals.	1931	July 2, 7, 13	3	47.8
Acid lead arsenate.....	4 lbs.—100 gals.				
Summer oil emulsion[1]..	1 —100	1931	July 2, 7, 13	3	62.8
Acid lead arsenate.. ..	4 lbs.—100 gals.				
Summer oil emulsion[2]..	1 —100	1932	July 5, 11	3	61.4
Acid lead arsenate ...	20 per cent				
Hydrated lime........	76 per cent				
Neutral white oil......	4 per cent	1931	July 2, 7, 13	4	46.6
Acid lead arsenate.....	20 per cent				
Talc.................	80 per cent	1930	July 2, 8, 17	2	42.8

[1]Proprietary emulsion; 65% oil.
[2]Proprietary emulsion; 65% oil used at rate of 1% actual oil.

Calcium arsenate has not been as satisfactory as lead at the strength at which it has been used. In spray form, 4 pounds of the calcium arsenate to 100 gallons of water produced dead areas in the leaves and desiccation and premature death of the tissues at the margins of the leaves.

MECHANICAL BARRIERS.—The use of talc and hydrated lime as mechanical barriers to newly hatched larvae and as deterrents to egg laying have not given satisfactory results. Oviposition records have indicated that hydrated lime did not prohibit egg laying to any marked extent. An average of 15.56 eggs per plant were taken on the plots dusted four times in 1928 with hydrated lime while an average of 20.16 eggs per plant were taken in the adjacent check areas. Larval reductions due to treatments with the talc and hydrated lime in spray and dust forms have all been comparatively small. In the single instance of an excessive dosage of talc (Table 3) applied in suspension in water severe injury occurred to the corn in the form of desiccation and retarded growth. The remaining plots treated with lime and talc were uninjured.

TABLE 3. LARVAL REDUCTIONS RESULTING FROM THE USE OF TALC AND HYDRATED LIME AS MECHANICAL BARRIERS

Material	Concentration	Year	Time and No. of applications	No. of trials	Per cent larval reduction
Hydrated lime........	Pure	1928	July 7, 12, 17, 27	2	23.6
Hydrated lime........	10 lbs.—100 gals.	1930	July 2, 8, 14	2	33.0
Talc.................	Pure	1930	July 2, 8, 14	2	34.2
Talc.................	10 lbs.—100 gals.	1930	July 2, 8, 14	2	21.0
Talc.................	1 lb.—1 gal.	1930	July 3, 9, 17	1	53.5

TABLE 4. LARVAL REDUCTIONS RESULTING FROM APPLICATIONS OF PYRETHRUM AND COMBINATIONS CONTAINING PYRETHRUM

Material	Concentration	Year	Time and No. of applications	No. of trials	Per cent larval reduction
Pyrethrum soap[1]......	1–800	1930	July 2, 9, 17	1	42.7
Pyrethrum soap[1]......	1–800	1931	July 2, 7, 13	3	48.6
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[2]..	1–100	1931	July 2, 7, 13	3	65.4
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[2]..	1–100	1929	July 4, 11, 16	3	72.0
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[3]..	1–100	1929	July 11, 16	1	54.4
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[3]..	1–100	1929	July 11	1	54.0
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[3]..	1–100	1929	July 4, 11, 16	3	58.6
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[2]..	1–100	1928	July 7, 12, 17, 27,	2	54.3
Pyrethrum soap[1]......	1–800				
Summer oil emulsion[3]..	1–100	1928	July 7, 12, 17, 27	2	62.9
Pyrethrum soap[1]......	1–400	1932	July 5, 11	3	37.8
Pyrethrum soap[1]......	1–400				
Rotenone...........	1–40000	1932	July 5, 11	3	53.6

[1]Proprietary compound containing 1.82 grams of pyrethrum per 100 cc.
[2]Proprietary emulsion containing 65% actual oil; viscosity 80–85 sec., Saybolt at 100 degrees F.
[3]Proprietary emulsion containing 65% actual oil; viscosity 150 sec., Saybolt at 100 degrees F.

PYRETHRUM.—Pyrethrum has not produced adequate larval reductions when used in soap form when two and three applications have been given. When combined with oil it appears to have slightly increased the value of the emulsions in reducing populations.

There has been no evidence of external injury or decreased yield from the use of pyrethrum and the pyrethrum and oil combinations have been found as satisfactory as the oil emulsions lacking this ingredient from the point of view of plant tolerance.

OIL SPRAYS.—Oil sprays have been used by themselves or as vehicles for the application of other materials for the past five years and have given quite marked larval reductions. The number of applications that can be applied without producing injury and the low concentrations that can be used because of the same reason have distinctly limited the kill that could be secured in these experiments. A summer oil having a viscosity of 80–85 sec., Saybolt at 100 degrees F., has been the most satisfactory of any of those used. The heavier and less volatile oils have been found dangerous to use because of the accumulation of the oil on the lower parts of the plants when more than one application has been applied. This accumulation has re-

TABLE 5. LARVAL REDUCTIONS RESULTING FROM SPRAY APPLICATIONS OF OIL

Material	Concentration	Year	Time and No. of application	No. of trials	Per cent larval reduction
Neutral white oil[1].....	1–100	1929	July 4, 11, 16	3	75.6
Neutral white oil[1].......	1–100	1929	July 11, 16	1	62.1
Neutral white oil[1].....	1–100	1929	July 11	1	54.2
Neutral white oil[2].....	1–100	1929	July 4, 11, 16	3	75.8
Neutral white oil[2].....	1–100	1929	July 11, 16	1	60.4
Neutral white oil[2].....	1–100	1929	July 4	1	56.7
Neutral white oil[3].....	1–100	1929	July 4, 11, 16	3	51.6
Neutral white oil[4].....	1–100	1929	July 4, 11, 16	3	58.1
Summer oil emulsion[5]..	1–100	1929	July 4, 11, 16	3	60.4
Summer oil emulsion[5]..	1–100	1929	July 11, 16	1	57.6
Summer oil emulsion[5]..	1–100	1929	July 11	1	43.1
Kerosene.............	2–100	1929	July 4, 11, 16	3	52.0
Kerosene.............	1–100	1929	July 4, 11, 16	3	50.6
Summer oil emulsion[6]..	1–100	1931	July 2, 7, 13	3	49.7
Summer oil emulsion[6]..	2–100	1932	July 5, 11	3	78.8
Neutral white oil......	1–100	1930	July 2, 8, 17	3	68.0
Pine oil..............	1–100	1930	July 2, 8, 17	3	78.1
Linseed oil...........	1–100	1929	July 4, 11, 16	3	72.0
Cottonseed oil........	1–100	1929	July 4, 11, 16	3	50.6

[1]Viscosity 80–85 sec., Saybolt at 100 degrees F.
[2]Viscosity 125 sec., Saybolt at 100 degrees F.
[3]Viscosity 180 sec., Saybolt at 100 degrees F.
[4]Viscosity 225 sec., Saybolt at 100 degrees F.
[5]Proprietary emulsion 85% oil.
[6]Proprietary emulsion 65% oil.
[7]Proprietary emulsion 65% oil; 2% actual oil used.

sulted in the premature death of the lower leaves and yield reductions have been evident. Although the greater part of the kill seems to have been produced by the one application put on at maximum hatching time, (Table 5) additional applications appear to be necessary in order to insure a reasonable degree of larval reduction. Emulsions containing 1 per cent actual oil have appeared to be the strongest concentration that could be used safely for three applications with any of the particular oils tested. Two per cent emulsions have been injurious to the plants when applied twice.

DERRIS.--Derris has been used with oil emulsions at a concentration of 1–800 and 1–1600 of a proprietary compound (Table 6). In these combinations it has been only slightly better than the emulsions lacking derris from the point of view of larval reduction. It has appeared to increase the injury produced by the emulsions but this increased injury has not been evident in yield reductions.

TABLE 6. LARVAL REDUCTIONS RESULTING FROM SPRAY APPLICATIONS OF DERRIS AND DERRIS-OIL COMBINATIONS

Material	Concentration	Year	No. and time of application	No. of trials	Per cent larval reduction
Derris[2]	1–1600				
Summer oil emulsion[1] . .	1–100	1928	July 7, 12, 17, 27	2	63.8
Derris[2]	1–1600				
Summer oil emulsion[1] . .	1–100	1929	July 4, 11, 16	3	64.1
Derris[2]	1–1600				
Summer oil emulsion . .	1–100	1929	July 11, 16	1	52.2
Derris[2]	1–1600				
Summer oil emulsion	1–100	1929	July 11	1	34.9
Derris[2]	1–800				
Neutral white oil	1–100	1930	July 2, 8, 17	1	67.2
Derris[2]	1–800				
Summer oil emulsion[1] . .	1–100	1931	July 2, 7, 13	3	55.2

[1]Proprietary emulsion 65% oil 80–85 sec., Saybolt at 100 degrees F.
[2]Proprietary compound; derris resin 5%, fatty acid 50%; inert matter 45%.

NICOTINE.—Nicotine sulphate has given variable results from year to year, depending probably on the climatic conditions at the time of application. Preliminary tests of this material in combination with an oxidized oil and applied during extreme heat in 1930 appeared to produce a high rate of kill. However, these results have not been duplicated in 1931 and 1932 and nicotine cannot be considered a satisfactory insecticide for corn borer by itself. It may have increased slightly the efficiency of oil emulsions. Free nicotine and tannic acid have given better results than nicotine sulphate or nicotine sulphate and oxidized oil in the one year in which they have been studied comparatively.

TABLE 7. LARVAL REDUCTIONS RESULTING FROM APPLICATIONS OF NICOTINE AND COMBINATIONS AS SPRAYS

Material	Concentration	Year	No. and time of application	No. of trials	Per cent larval reduction
Nicotine sulphate (40%)	1–800				
Potash fish oil soap.....	1–400	1931	July 2, 7, 13	3	36.0
Nicotine sulphate (40%)	1–400				
Potash fish oil soap.....	1–400	1932	July 5, 11	3	8.9
Free nicotine (50%)....	1–400				
Tannic acid...........	1–200	1932	July 5, 11	3	56.7
Nicotine sulphate (40%)	1–400				
Oxidized oil[1]..........	1–200	1932	July 5, 11	3	46.6
Nicotine sulphate (40%)	1–800				
Summer oil emulsion[2]...	1–100	1931	July 2, 7, 13	3	63.3

[1]Proprietary compound; oxidized petroleum hydrocarbons 80%; inert materials 20%.
[2]Proprietary emulsion containing 65% oil; 1% actual oil used.

DISCUSSION.—Such attempts as have been made to reduce corn borer infestation and population by insecticidal applications have for the most part been unsatisfactory. The corn used has been making a rapid growth and has been easily injured at the time that applications of the poisons have been made and the margin of safety between materials capable of reducing populations and producing injuries to the plants has seemed extremely low. Insecticides applied as dusts have been less effective in reducing populations than the same insecticides when applied in spray form. Hydrated lime and talc have been unsatisfactory when used as mechanical barriers to young larvae. Such oils as have been used have required three applications to give satisfactory larval reductions at safe strengths. Nicotine and pyrethrum have not given satisfactory results when used by themselves and have along with derris, added little if anything to the oil emulsions from the point of view of reducing infestations. Arsenate of lead has produced too low a larval reduction when used by itself to seem of practical value but when used with an oil has given reasonable kills with three applications. Barium fluosilicate by itself and in combination with dilute oil emulsions has given marked larval reductions but these reductions have been accompanied by some injury. Calcium fluosilicate, although tested only during one year, appears at this time to be the most satisfactory insecticide for use against the European corn borer that has been included in these studies.

SOME ECOLOGICAL ASPECTS OF EUROPEAN CORN BORER ABUNDANCE

By L. L. Huber and J. B. Polivka

It is the purpose of this paper to review briefly the behavior of the European corn borer in the Lake Erie region, specifically in Ontario, Canada, and in Ohio. Published records have indicated the differences in population, not only from year to year but also in various types of habitats. In many instances, certain conditions of weather or soil, or both, have been cited as probable or specific controlling factors. For example, a period of abnormal temperature during moth flight may reduce egg deposition. It should be remembered, however, that the significance of such a factor is only relative. Furthermore, the study of certain environmental factors in combination still falls short of the requirements of a major biological problem. It seems, therefore, that the ultimate interpretation of the effects that factors produce on the behavior of the borer will have to be expressed in terms of the physiology of the organism as a whole. This is to say, that it would be desirable to obtain and use some measurement which represents an integration of the total environment. The yield of corn in the area where the borer is present approaches such a desideratum.

The corn yield data used herein represent the entire State of Ohio and the entire Province of Ontario, whereas the estimates of corn borer abundance represent only a small portion of these two regions. While it is desirable to correlate corn borer behavior with yields in the particular areas where the borer is abundant, it remains true that the trends of yields in the areas where the insect is relatively abundant are the same as for the regions as a whole. Such deviations as exist are not considered important for the present purpose. In other words, to the extent that corn yields over these entire areas represent the general trend in the areas where the borer has been present for some time and to the extent that yields represent an integrated measurement of the environment, particularly during the growing season, it is possible to use them to express certain ecological relationships.

Published records[1] indicate that in Ontario there were only 2 poor corn years from 1909 to 1923, inclusive (Fig. 54). Furthermore, from 1909 to 1915, inclusive, the yields were considerably above normal

[1]Ontario Department of Agriculture. Statistics and Publications Branch, Crop Bulletins, 1909–1931.

for 7 years in succession, and from 1918 to 1923, inclusive, they were normal or above for 6 successive years. On the contrary, from 1924 to 1931, inclusive, there was only one year in which production was

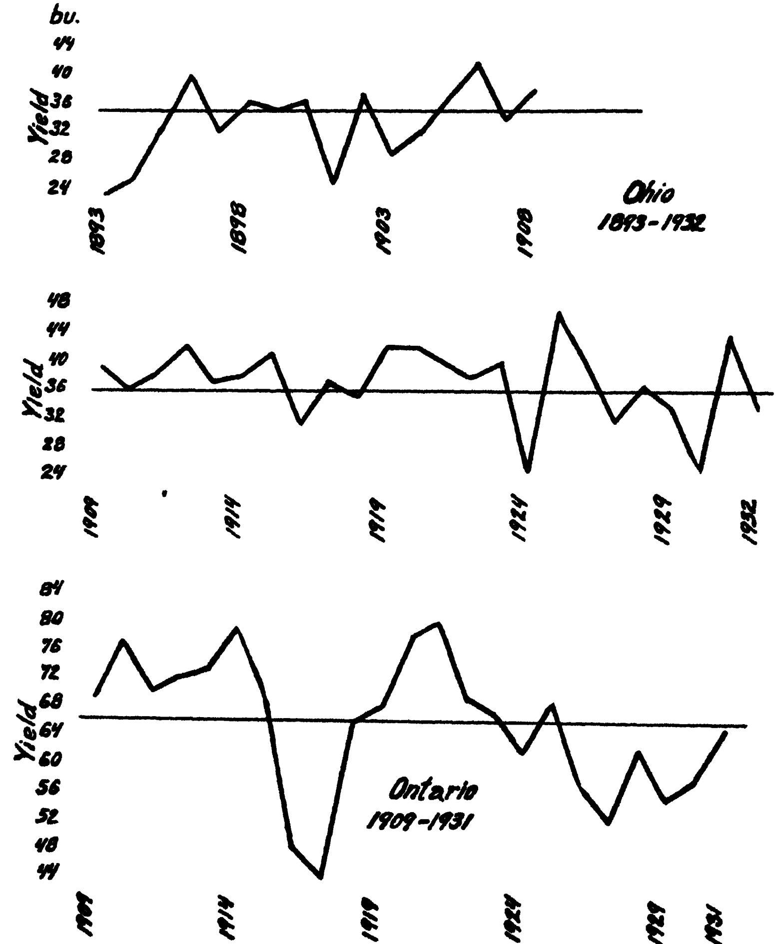

Fig. 54.—Showing yield of corn per acre in Ohio and in Ontario, Canada, from 1893–1932, and 1909–1931, respectively.

above normal. It should be pointed out, however, that the low yield of 1926 was due, in part, to corn borer damage; to a lesser extent this is perhaps true for the few years immediately preceding 1926. In Ohio, the expected yield of corn is based on records for 40 years. An examination of these records[a] shows that from 1905 to 1926, in-

[a]United States Department of Agriculture, Year Book, 1893–1932.

clusive, a period of 22 years, the yields were above the expected for 17 years, that during this time no poor corn years occurred in succession, and that prior to 1905 and since 1926 the tendency of production has been subnormal. In the entire 40-year period, 2 normal or above corn years have appeared in succession 15 times, whereas 2 subnormal years have appeared only four times in succession. Without going into further detail, it should be apparent that insofar as these statements suggest the expectations of the future they are of considerable importance. This is particularly true when the causal and concomitant relationships of borer behavior and corn development are remembered.

Records show that from the time the borer was discovered in Ontario in 1920 to the time when heavy losses occurred in 1926, the population increased steadily. On the contrary, from 1927 to the present there has been a continued tendency toward maintaining a rather low population. These periods of high and low trends have corresponded to the periods of above and below normal corn production, respectively. Similar records in Ohio suggest that up to and including 1926 the borer increased quite rapidly. In 1927, there was a tendency to maintain the *status quo*, whereas in 1928, a better than average corn year, the population again reached a new level. When corn production fell below normal in 1929, the borer population showed no extraordinary upward trend but rather a tendency toward maintaining the 1928 level. However, when yields continued downward in 1930, corn borer population suffered a severe reduction. On the other hand, with the occurrence of a good corn year in 1931, the insect tended to reach its former level. In 1932, with a poorer than average condition of corn through the growing season, the borer again showed only a negligible tendency to increase.

On the basis of these facts, it appears that certain general, though tentative, conclusions may be drawn: (1) That ecological conditions, on the whole and especially since 1926, have been unfavorable to the borer in Ohio; only in isolated areas or on ecological islands have high populations been persistent. (2) That the corn borer, unless control is effected, probably will cause serious losses in wide areas when conditions are normal or above for a period of 2 or more years in succession, although this is not to say that losses will not occur the first year, particularly if the overwintering population is sufficiently high. (3) That when an unfavorable year follows a favorable one the borer population is likely to manifest a tendency to maintain the

status quo; but, if the second and succeeding years are also below normal, the population probably will show a significant decrease. This, of course, does not preclude the possibility that an extremely high population accompanying a period of favorable years may cause damage the following year even though ecological conditions are subnormal.

SUGAR CANE BORER CONTROL BY *TRICHOGRAMMA* COLONIZATION IN LOUISIANA IN 1932

By W. E. Hinds, B. A. Osterberger and A. L. Dugas, *Louisiana Experiment Station*

Abstract

This paper reports experimental work with colonization of *Trichogramma minutum* for control of the sugarcane borer (*Diatraea saccharalis*) in corn and cane fields in Louisiana. It is shown that colonization increases very abruptly the parasitism percentage in colonized fields of cane and corn and that the parasites spread quite promptly into adjacent fields. The average percentage of borer eggs destroyed in colonized and adjacent fields was about 28% greater than in comparable check areas for the latter portion of the season. This higher destruction of borer eggs resulted in a decided decrease in the proportion of stalks bored, joints bored and moth population produced per acre in millable cane. About 6000 millable stalks per acre were saved apparently by parasite colonization. By decreasing the borer attack on cane there was found to have been an average saving of from 21 to 25 pounds of sugar per ton of cane in an average of all protected areas. The cost of colonization work averaged less than $1.00 per acre.

Several previous reports upon this project have appeared in the Journal of Economic Entomology. The subject is continued because it appears that, contrary to the expectations and opinions of various specialists in biological control of insects, the work of establishing early season colonies of *Trichogramma* in and adjacent to cane fields is actually producing beneficial results in Louisiana and further progress has been made in the measurement of the benefits therefrom.

It is impossible to present more than a summary survey of the mass of data which has been accumulated on this subject. Many phases of the work can not be mentioned and the discussion must necessarily be too brief to cover the subject adequately or perhaps convincingly for those outside of the sugarcane belt. In this work we shall speak of borer damage alone although we know that in addition to the

damage done by the sugarcane borer there is a certain measure of damage occurring frequently also due to fungus diseases which in most cases secure their entrance primarily through the lesions caused by the cane borer larvae.

The general plan for the work for 1932 followed very closely that of 1931, except that somewhat smaller numbers of parasites were released in the colonized areas, averaging about 6000 per acre this season, and practically only one release was made for the season. The releases were made principally at the time that eggs were being laid for second or third generations. Many colonies were placed in fields of heavily borer infested corn closely adjacent to cane fields and check areas of both corn and cane were chosen. The cane checks were similarly exposed to borers coming from corn but with no parasitization of borer eggs except that occurring naturally. In every case the check areas were carefully selected to be as fully comparable as possible with the colonized and adjacent areas as an average, the latter two groups being considered together as "protected" areas. The initial borer infestation in June was higher in corn than in cane areas but varied little in the average of all corn or cane areas included in each group of "colonized," "adjacent" and "checks".

Borer egg collections were made in all test areas before any colonization and every three weeks thereafter until September 10. A definite time unit for egg collection in each area was used so that to some degree the abundance of borer egg batches might be compared. There is known to be a very considerable variation in the susceptibility of different varieties of sugarcane to attack by the sugarcane borer. Therefore comparisons were made only between fields of the same variety and planting date, or age of cane, and with previous cropping history uniform in each case. In a number of cases deliberate selection was made of locations which we had watched closely for several seasons and had known, therefore, that these were regularly very heavy infested areas where the damage to cane had been exceedingly heavy for several seasons past. Furthermore the borer population known to occur in these areas early in the spring of 1932 was exceptionally high. In these cases test comparisons could be made between colonizations at one side of a long stretch of cane consisting of several cuts, with checks at the opposite side of the stretch but where the exposure to borer infestation was similar. The results found at the end of the season in several such instances are particularly striking and convincing when considered in detail and with full knowledge

of the situation in each case. Rather than to depend upon a few such striking instances, we prefer to base our conclusions primarily upon the accumulated mass of data secured from a large number of fields representing a wide range in varieties of cane and in plantation practice. We believe that this basis indicates most surely what the average planter may reasonably expect where colonization work is done properly.

Also this season we have been able to make some records on quite a large series of fields where the work was done by county agents and plantation men rather than by members of the Experiment Station staff. In these cases where the work was done according to our instructions and at the proper time their results in the increase in parasitism, reduction in borer infestation and increase in yield and in sugar content of cane in colonized areas as compared with their own checks, have been practically parallel with those obtained in our own series of experiments.

PROGRESS OF PARASITISM IN "COLONIZED," "ADJACENT" AND "CHECK" AREAS, IN 1932. Altogether we have examined under microscopes more than 400,000 borer eggs during the season to determine the progress of borer infestation and *Trichogramma* parasitism in various areas.

The first series of colonizations was made in South Louisiana June 13–17 and included 20 fields of corn and 8 of cane at that time. The primary purpose in colonizing in these fields of corn was to develop as rapidly as possible a large local center for the development of *Trichogramma* from which the wasps might spread later into nearby fields of cane. We shall consider first the progress of parasitism in two groups of corn fields. In these the borer infestation and natural parasitism were, on the average, very similar before the time of colonization in one group.

TABLE 1. PROGRESS IN *Trichogramma* PARASITISM IN COLONIZED AND CHECK FIELDS OF EARLY CORN, 1932

(The percentages given are *weighted* averages)

		Weighed average %		
No. of fields averaged	Test	Coll. 6/13–17	Coll. 7/1–9	Coll. 7/25–30
8	Check	17.4	36.4	53.5
11	Colonized	16.3	72.7	82.8

In the check corn fields the natural parasitism was slightly higher at the start than in the colonized. During the next six weeks natural parasitism in check areas increased three fold, while in the colonized

areas, with the addition of about 6000 parasites per acre there was an increase to five fold.

Naturally as the corn fields matured at about the latter part of July or early in August, both borer moths and parasites spread from

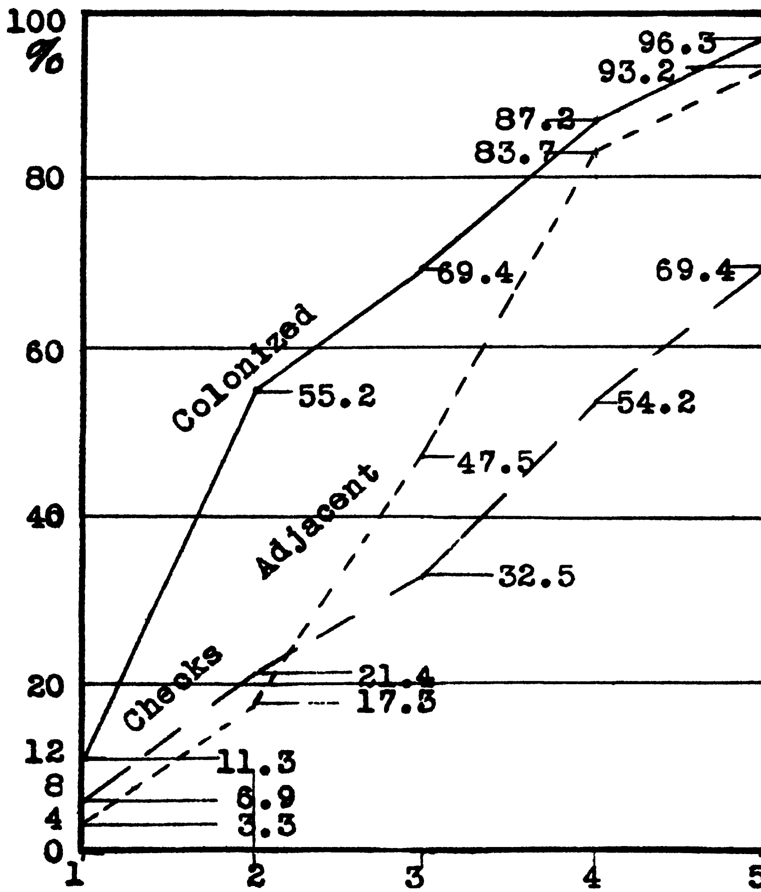

Fig. 55.—Progress of Trichogramma Parasitism, Colonized, Adjacent and Check Fields South La., Median collection dates: 1) June 15; 2) July 5; 3) July 28; 4) August 27; 5) Sept. 8, 1932

these areas for a very considerable distance. The colonized corn fields must necessarily be dropped from consideration thereafter but the beneficial effects of colonizing these corn areas are shown strikingly in the very rapid increase of parasitism and the very highly effective control of the borer shown in the fields of cane adjacent to the colonized corn. (See graph, Fig. 55.)

Under average conditions of natural parasitism, cane growers well know that there is very grave danger of serious damage to cane grown closely adjacent to fields of early maturing corn. It is quite contrary to usual experience to have such adjacent cane fields less damaged by borer at the end of the season than similar fields grown at a distance from the corn areas.

The late season establishment of *Trichogramma* in many cane fields was shown by observations made at Plaquemine between July 26 and August 9. There on 8 plantations, in an examination of some 24 fields of cane, no parasitism whatever was found in 6 fields although borer eggs were abundant in some of them. Fourteen showed a parasitism of less than 20% with an average of 5.8%. The maximum found in one of these 24 naturally parasitized fields was 69%, while it happens that in an *average* of 22 colonized fields of cane in South Louisiana at the same period 69.4% of borer eggs had been parasitized. It would appear that the chances were at least 20 to 1 in favor of the parasitism in colonized areas reaching as high as 69% by the first of August, as compared with parasitism naturally developed.

In order to present a summary view of this mass of data as briefly as possible we have placed it in the form of a graph which appears herewith.

The progress of parasitism through the season is only one of several indices by which we measure the benefits of colonization work. From an examination of the graph it is quite clearly shown that in colonized areas there is a very rapid increase of parasitism during the first few weeks after the colony is established. The development in the check areas which at the middle of June were intermediate in parasitism between the colonized and adjacent fields, continues steadily and in nearly a straight line through the season to an average maximum of 69.4%. In the "adjacent" fields with only half the parasitism occurring in the checks at the beginning of the examinations, the development is parallel with that in the checks for the first few weeks and then as parasites spread from the early parasitized colonized areas into the "adjacent" fields the rate of increase in the "adjacent" fields rises very rapidly indeed until it approaches closely the percentage occurring in the colonized areas. The development in the check areas never overtook that in colonized and adjacent areas even in a comparison of individual field records, although by mid-season the infestation by borers in many of the check fields exceeded that in

any of the colonized or adjacent fields. A close study of individual field records shows clearly that the abundance of host eggs is not the only factor that governs the development of parasitism in any particular field. There is also a factor of the time at which the parasitism starts. When this start is late two generations of borers may have occurred and a great deal of damage may have been done to the cane which cannot be wiped out by late season high parasitism of borer eggs. *Trichogramma* does not develop spontaneously any more than does *Diatraea*. There is strong evidence that *Trichogramma* does not survive the winter in many cane fields and they may not reach all fields by their natural spread until after two or three generations of borers have developed and injury to the cane is already severe. We believe that *Trichogramma* control of *Diatraea* to be really effective must start early in the season, at least as early as borer infestation becomes moderately abundant, and this host condition may occur at the beginning of second, third and sometimes even as late as the fourth generation of borers.

Trichogramma COLONIZATION EFFECTS UPON STALK INFESTATION AND MOTH POPULATION PRODUCED IN MILLABLE CANE, 1932. In securing these correlations all examinations were made by the same group of workers under the supervision of one man so that there was uniformity as to methods and personal equations throughout. The stand of cane per acre was determined on the basis of averaging the figures found at four representative locations situated some distance in from the ends and edges of each cut. In these locations also, 100 stalks were stripped and thoroughly examined for any signs of borer and those showing one or more borer burrows per stalk were classed as "bored." The emergence holes are conspicuous and were recorded for each group of stalks examined. On the basis of "stand" and ratio of emergence holes per 100 stalks, the moth population per acre in millable cane was determined.

Trichogramma COLONIZATION EFFECTS ON BORER EGG PARASITIZATION, PERCENTAGE OF STALKS, NUMBER OF BORER EMERGENCE HOLES AND MOTH POPULATION PER ACRE, 1932

TABLE 2. PROGRESS OF *Trichogramma* PARASITISM 1932

Test group and No. fields	6/13–6/17	7/1–7/9	7/25–7/30	8/15–8/24	9/6–9/10
(A) 12 Col'd..........	5.7	36.8	64.3	87.2	96.4
(B) 18 Adj...........	3.1	14.4	47.5	83.7	93.2
(C) 21 Check.........	1.8	9.4	23.7	58.0	69.3

TABLE 3. BORER INFESTATION IN MILLABLE STALKS AND MOTH POPULATION PER ACRE, 1932

Number examined	Stalk Infestation: With 1 or more burrows %	Joints bored %	Moth population in mill cane: Emergence holes number	Average No. stalks per 1 emergence hole	Moths per A. average number
(A) 1200......	64.0	13.5	173	7.0	3,422
(B) 1800......	59.1	12.3	146	12.3	2,164
(C) 2100......	93.0	31.8	793	2.6	6,057

From the data in Tables 2 and 3 it appears that "protected" areas (colonized and adjacent taken together) show the destruction of borer eggs to average fully one-third higher than in checks and that as a consequence there follows a reduction averaging about 33% in the percentage of stalks bored and averaging 60% in the percentage of joints bored. Furthermore the total moth population produced in millable cane through the season was only 46.1% of that in checks. These results are closely consistent with those found in 1931.

Trichogramma COLONIZATION EFFECTS UPON PROPORTIONS OF MILLABLE AND UNMILLABLE CANE. In the same fields a further study was made to determine the average stands of millable and unmillable stalks per acre. This was done by examining larger plats at four representative sections of each field and averaging the results for that area. Row-feet measurements were taken also and the proportion of unmillable stalks killed by borers was determined. All of these examinations were made by one man following uniform methods.

TABLE 4. BORER CONTROL MEASURED BY MILLABLE AND UNMILLABLE CANE—1932

Type and number fields	Number stalks examined	Original stand shoots per A	At harvest: Millable number	At harvest: Unmill - able number	Unmillable Killed by borer No.	Unmillable Killed by borer %	Millable canes saved by colonization. Av. Number per acre
31 Protected	12,400	34,880	25,288	9,592	7,499	78.2	6,000
28 Checks...	11,200	35,720	19,289	16,431	12,859	78.3	

In comparing these two sets of areas it is very striking that, while the original stand of sprouts was practically equal, the borers destroyed many more shoots in the check areas than in the protected areas. The difference amounted to 6,000 stalks per acre and this factor alone amounts to 25% of the yield in millable stalks secured on the average of all protected areas. We believe that this is the first time that a direct study of borer damage in the form of unmillable cane has been made in Louisiana. The conclusion as to loss from borer infestation in this form is supported also by field weight records on many plantations.

TABLE 5 *Trichogramma* COLONIZATION EFFECTS UPON PERCENTAGE OF STALKS BORED,[1] JOINTS BORED AND SUGAR PER TON OF CANE, 1932

Protected: Variety of cane	Protected: Number of fields averaged	Protected: Percentage Stalks bored	Protected: Percentage Joints bored	Protected: Sugar per ton of cane aver lbs	Checks: Sugar per ton of cane aver lbs	Checks: Percentage Joints bored	Checks: Percentage Stalks bored	Checks: Number of fields averaged	Checks: Variety of cane
213 St	5	73 3	15 3	178 90	155 71	30 4	95 0	5	213 St
213 St	2	61 5	13 6	151 51	141 56	41 2	99 0	2	213 St
213 St. & Pl	5	76 2	17 5	187 57	152 68	37 8	95 5	4	213 St & Pl
213 St & Pl	2	90 5	10 9	198 78	173 21	42 0	100 0	2	213 St & Pl
Total and average 213	14	75 1	15 4	180 94	155 11	36 4	96 5	13	213 total & aver
		(Average increase 25 83 lbs per ton with POJ 213)							
36-M	2	34 5	5 7	143 19	126 51	29 7	78 0	2	36 M
36-M	1	16 0	3 6	201 06	180 78	28 1	97 0	1	36 M
Total and average 36-M	3	28 3	5 1	162 48	144 60	28 8	84 3	3	36 M total & aver
		(Average increase 17 88 lbs per ton with POJ 36 M)							
807	2	48 5	8 8	155 94	131 88	27 33	98 0	1	807
807	1	41 0	7 0	170 53[2]	180 13[2]	26 8	90 0	1	807 (McC)
807	1	75 0	10 9	195 33	176 71	19 8	89 0	1	807
Total and average 807	4	53 2	9 2	169 43	162 91	24 5	92 3	3	807 total & aver
		(Average increase 6 52 lbs per ton with 807)							
234 Pl. total	1	71 0	13 9	210 00	175 96	31 9	94 0	1	234 Pl total
		(Average increase 34 04 lbs per ton with 234)							
Co 281 total	1	66 0	15 7	185 65[2]	189 89[2]	36 8	94 0	1	281 total
Composite: All protect	23	64 6	13 7	178 0	157 08	33 1	89 4	21	Composite: all checks
		(Composite average increase 20 92 lbs per ton for all varieties)							

[1]Stalks are classed as "bored" if they show one or more borer burrows of any size Many of these may be small or shallow burrows and cause no measurable injury to the stalk as a whole The same is true for "joints bored"

[2]These two sets of fields (807 and 281) were grown on the same plantation Being the only comparisons of 1932 that were *apparently* "out of line" with the general trend, a special investigation was made to find the explanation It was then learned that a few years ago Bayou Teche mud had been pumped onto both "adjacent" fields which have since produced regularly more tons of cane per acre but with a considerably lower yield of sugar per ton than the checks which had no mud added to them The results in these two cases are therefore *not* out of line. The owner remarked "I am surprised that there is not more difference in sugar content in favor of the check areas."

Trichogramma COLONIZATION EFFECTS UPON SUGAR PER TON OF CANE.—In addition to the foregoing studies, samples of cane were taken from as many of the test fields as possible to determine the average sugar content and the extent to which various degrees of borer infestation had affected the sugar produced. The method of taking samples was recommended by Professor W. G. Taggart, Assistant Director, Louisiana Experiment Station and in charge of Sugar Cane Investigations, as having been found to give consistently dependable field average analyses. The samples were taken by one man selecting at random 30 stalks scattered widely through the field and all analyses were made through the same mill and by the same chemist at the Louisiana Experiment Station.

In Table 5 we are able for the first time to present for 5 varieties the very significant correlations existing between borer infestation and the amount of sugar produced per ton of cane. Our investigations have included a much larger number of fields of POJ 213 cane than of any other variety because of the generally well known susceptibility of this variety to both borer attack and to red rot infection. The large number of fields represented gives the figures for sugar saved per ton of cane a very high degree of dependability for 213 (25.83 lbs.) and for the composite average for all varieties (20.92 lbs). The figures show also something of the variation which exists among cane varieties in susceptibility to injury by borer and red rot combined. Even with the variety CP 807 which appears in this table—and in all of our other studies—to be least injured in sugar content, the saving is sufficient to justify colonization work.

COST OF COLONIZATION WORK.—The cost of colonization work in 1932 ranged from about 80c to $1.20 per acre. A fair average figure covering the market cost of 6,000 parasites and the small amount of labor required in their liberation is $1.00 per acre. Very decided improvements have been made during the year in the type of container used in shipping out the unit numbers needed per acre.

SUMMARY AND CONCLUSIONS

1. In corn, among 8 comparable check fields the natural parasitism increased between June 15 and July 30 from 17.4% to 53.5% average (an increase of three-fold), while among 11 colonized areas averaging 16.3% parasitism before colonization, the addition of 6000 *Trichogramma* per acre enabled these fields to show 82.8% average parasitism at the end of July (an increase to five-fold).

2. Among the *cane* fields compared, the natural parasitism occurring at the start was 6.9% in all checks, 11.3% in all colonized and 3.3% in all adjacents which received most of their parasite supply from nearby, colonized corn fields. In three weeks the percentages had increased five-fold in colonized, five-fold in adjacent and three-fold in checks. Through the balance of the season the parasitism in colonized and adjacent areas continued far higher than in the checks, averaging approximately 28% above checks to Sept. 10.

3. Correlation studies show that in all check areas there was an average of 31.8% of the cane joints bored and a moth population of 6,057 produced in millable cane through the season. Compared with these figures all colonized fields showed 13.5% of joints bored and 3,422 moths per acre while adjacent fields had 12.3% of joints bored and 2,164 moths per acre.

4. With an initial total stand averaging 34,880 sprouts in all 31 protected areas and 35,720 in 28 checks, there were 19,289 millable stalks per acre produced in checks and 25,288 in all protected areas. The difference of 6000 millable stalks per acre, or a saving of over 30% of the check stalk yield, is indicated as one benefit from colonization work.

5. Finally, we find a consistent and very significant saving in pounds of sugar produced per ton of cane. The *saving* ranges from 6.52 lbs. per ton with 807 (the most resistant variety) to 25.83 lbs. per ton with 213. The general average saving shown as a composite of all varieties was 20.92 lbs. of sugar per ton of cane.

6. The cost of colonization work averaged $1.00 per acre in 1932.

7. Louisiana cane growers may depend upon this method of borer control, which has shown consistent benefits during each of the past six seasons. The measurement of actual benefit has been shown more clearly, fully and convincingly in 1932 than through the work of any preceding year.

8. Our general conclusion from all of this work is that *Trichogramma* colonization, as tested by Experiment Station workers and practiced by numerous growers in 1932, resulted in a very substantial reduction in cane borer multiplication and damage to sugar cane, and a corresponding increase in tonnage of millable cane and in the amount of sugar produced per ton of cane.

TECHNIQUE IN THE MASS PRODUCTION OF *TRICHOGRAMMA*

By E. Graywood Smyth, *Consulting Entomologist*

ABSTRACT

A simple and cheap method is described for rearing *Trichogramma* in very large numbers. The economic soundness of biological control of cane borer by this method is attested by the success of the results obtained. The various advantages of the method over others that have been put forward are enumerated Beyond its simplicity, the principal advantage claimed for the method is the ease with which restocking of moth breeding houses is accomplished.

Notable strides have been made in the past five years in the artificial propagation and use of the egg parasite, *Trichogramma*, to control such serious crop pests as the cane borer, the rice moths, the codling and Oriental fruit moths, and others. So extensive has become the use of the parasite, in widely separated parts of the globe, that the economic question of reduction of cost involved in its handling is a matter of great concern to those agencies who utilize this method of biological control. Any simplifying of the technique of mass production which reduces handling, and thus reduces cost, may be considered a step forward.

The author has been engaged for three years in control of the cane borer, *Diatraea saccharalis* Fab., on a large commercial scale by this method. The technique here described was very largely devised from experience gained during that time. Significant is the fact that, as a result of mass colonizations of *Trichogramma* wasps reared by this technique, borer damage was so reduced that the purity and sucrose of the cane (and hence the sugar content) showed a very considerable increase, in a large series of fields colonized with parasites, over those registered in other fields of the same plantation not so colonized. These conclusions were not arrived at from small samplings, but from official company figures of total yields. A study of costs and amortization has shown the system of biological control to be economically sound. Far from discontinuing the work after a three year trial, it is being increased by doubling the parasite rearing capacity.

The method of securing the oviposition of the wasps in petri dishes has faithfully served its usefulness, and is being displaced by other methods that involve less manipulation. A method recently devised by Flanders, in California, by which egg cards in multiple rows are slid into a box specially constructed for oviposition, which accom-

modates up to five million eggs at one time, serves very well where parasites are to be shipped, or are intended for use in orchards where the egg cards are suspended in trees. For control of the cane borer on large sugar cane plantations, however, the technique here described has been found both simple and expedient.

Mason jars are used, and the *Sitotroga* eggs are secured to the glass on the inside of jar by means of an aqueous solution of gum arabic, which is preferable to paste because odorless and perfectly clear. A little benzoate of soda is used to preserve the adhesive, which is painted in on one side of the jar with a long handled brush. It is painted in a series of bands crossing one another at right angles, so the deportment of the wasps may be later observed in the clear squares between the bands. Five or six disks of filter paper clamped on beneath the glass top of jar make a parasite proof cover. A minute or so after the adhesive is applied, a given number by weight of *Sitotroga* eggs is introduced, cover clamped on and the jar shaken well, which distributes the eggs evenly over the pasted bands. Jar is left open half an hour for the adhesive to dry, and is then inverted mouth to mouth over a similar jar containing parasitized *Sitotroga* eggs from which the Trix are about to or beginning to issue. (Jars containing many living Trix may be opened and handled without loss of parasites by placing a jar with bottom end toward strong light, when the wasps all flock to that end.) The jars are effectively secured together by means of a strip of adhesive tape (such as J. & J.) half an inch wide and ten inches long, bound about the circumference of the mouths and overlapping equally the lips. Stretched slightly, the tape takes advantage of the slight flare on the lips of jars, gripping them very tightly together. There is no loss of parasites. We use Atlas E-Z Clamp quart jars, and two jars thus bound together may be handled considerably without separating.

The two superimposed jars are placed in diffused artificial light for 24 hours, in a temperature of 29 degrees Centigrade, that with fresh eggs uppermost as the wasps crawl upward and have a tendency to remain near the top. Or the jars may be placed horizontally in a wooden box having three sides removed and replaced with thin paper, beneath artificial light, in which case the jars of parasitized eggs should be covered with dark cloth or carbon paper, so the wasps will pass into the jars of fresh eggs. Plate 33, Fig. 1, shows a lighting unit thus arranged, the carbon paper having been removed to show all the jars. Care should be taken to protect the jars, during

oviposition, from direct sunlight or even daylight, which tends to cause too much activity of the parasites and to draw them away from the eggs.

Before separating, jars are placed with the bottom of the one which contained the hatching Trix toward strong light, when most of the wasps will swarm back into it from the jar of fresh eggs. It is then detached and covered as described, with disks of filter paper, and is ready to be taken to the field for liberation of the parasites. The number of Trix lost through dying within the 24 hours, or from having remained in the other jar, will rarely exceed 15 to 20 per cent of the total, and is often less (many Trix will not have issued within the first 24 hours after hatching begins), and the fresh eggs, in number about equal to those in the jar that contained the wasps, will have become now mostly parasitized.

A calculation is easily made of the number of Trix to be liberated. Four small rectangles (about 3 by 12 mm.) are inscribed over the eggs on the outside of glass with India ink, so distributed as to give representative counts, and the number of parasitized and of unparasitized eggs within each rectangle is recorded. From these counts is derived the average parasitism of the eggs in the jar, and thus the number of parasites contained. Deducting 20 per cent of these for the losses sustained during oviposition gives a fairly accurate figure of the number to be liberated. If greater accuracy is desired, another simple method may be used. When pasting the eggs, 80 per cent of a lot may be secured against the glass on inside of a jar and 20 per cent pasted on a card, which is inserted in the same jar at time of oviposition. Thus if 200 thousand eggs are to be exposed to Trix in a jar, 160 thousand should be pasted as described against the glass on inside, and 40 thousand pasted on a card that is inserted in the same. When all are well parasitized the card is isolated in another jar, and kept for use in reovipositing, while the jar that contains 160 thousand is taken direct to the field when the wasps hatch. Thus the exact number of Trix liberated may be known.

After the separation of two jars bound together for oviposition, that with fresh eggs is bound in same manner with adhesive tape in inverted position over a jar containing fumigated corn, or other suitable grain, and thus left for six days. (See Plate 33, Fig. 2.) In this way the *Sitotroga* eggs that have not become parasitized by the Trix are not lost, but the larvae hatching from them are salvaged and later returned to the *Sitotroga* breeding rooms, and such living wasps

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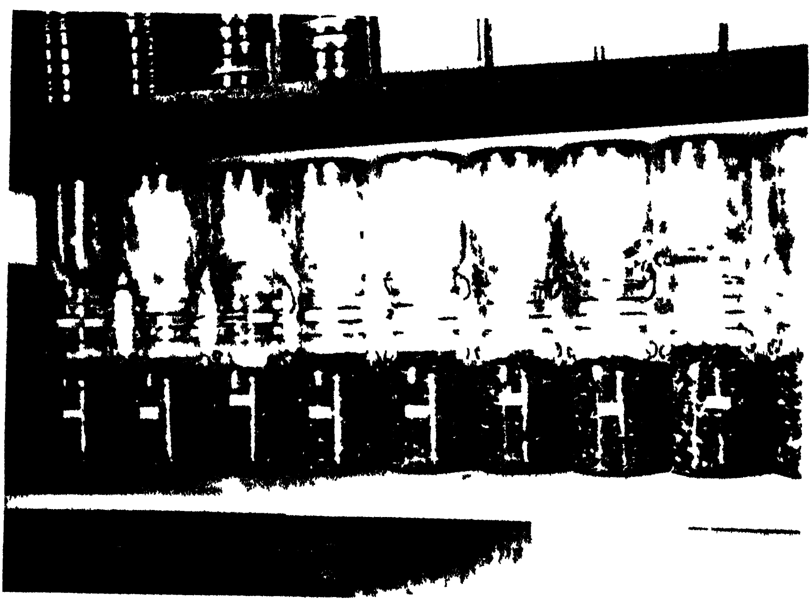

2

1—Simple and economical lighting unit for use during oviposition of the wasps in the propagation of *Trichogramma*

2 Jars of *Sitotroga* eggs inverted over jars of corn to conserve the larvae hatching from such eggs as may not have become parasitized.

as may remain in the jar will continue ovipositing. This saving of larvae from the unparasitized *Sitotroga* eggs is an important feature of the method. If a jar contains 100 thousand *Sitotroga* eggs and 15 per cent of the eggs have failed to become parasitized by the Trix (the usual parasitism ranges around 85 per cent), and we allow for a failure of perhaps a third of these to hatch through mechanical injury, it still means that something near ten thousand *Sitotroga* larvae are being returned to the breeding rooms from a single jar of eggs, that would be lost by most other methods. (A quart Mason jar will hold somewhat over two thousand grains of corn, which is sufficient to bring to maturity ten thousand *Sitotroga* moths.)

An estimate of the value of this saving is simple. If the weekly *Sitotroga* egg production is three million eggs, and that number is weekly subjected to Trix attack (on the basis of five jars daily of 100,000 eggs each), the weekly recovery of *Sitotroga* larvae from unparasitized eggs will be in the neighborhood of 300 thousand. It requires just about 200 thousand *Sitotroga* moths to produce three million eggs, at the average rate of 15 eggs per moth (or 30 eggs per female). Thus, if we are taking from the breeding houses only 200 thousand moths per week, but are returning 300 thousand young *Sitotroga* larvae per week, we are automatically more than sustaining the reproductive powers of the moths, and egg collections can continue indefinitely until the grain is exhausted.

A turning of five full jars of infested corn daily into the *Sitotroga* breeding rooms amounts to about an addition of four bushels monthly. This might result in a crowding of the grain bins unless adequate provision be made for the addition, so that it presupposes a sort of rotation in the filling of the bins with corn. It has been found expedient to start with bins about half full only; then, when fresh larva-infested corn is added, space is easily made for it, and the date of adding the corn is placed on the box. If one is using the type of breeding rooms designed by Hinds and Spencer (which contain bins of sliding boxes, like drawers, built in 8 tiers of 8 boxes to the tier, the boxes containing a bushel of corn each and the room thus holding 64 bushels), and the breeding is started with boxes only half filled, corn may be added at the rate of two bushels per month to each room for a year or more before crowding necessitates a removal of some of the used corn. The continued addition of infested corn to the bins, however, and the uninterrupted breeding of the moths, are predicated

upon the ability of the operator to keep his breeding houses free from contamination.

The breeding of *Sitotroga* moths in great quantities from grain, simple though it may appear, becomes very soon hampered by the invasion of other grain pests that are very undesirable for our purposes, in spite of all precautions that may be taken. Frequent opening of the door in the removal of eggs permits unavoidable entrance of other insects. These may include other grain moths, like *Ephestia* and *Plodia*; one or more of the grain beetles, *Calendra, Cathartus, Silvanus, Tribolium, Araecerus, Rhizopertha* and *Tenebrioides*; various species of mites that attack the moths; and Hymenopterus parasites of *Sitotroga*. Avoidance of these undesirable visitors becomes a question of the ability to eliminate them when they appear and before they cause trouble, and requires alertness and ingenuity. These questions we have successfully solved, and they will be discussed in another paper.

Another requirement, to accomplish uninterrupted breeding of *Sitotroga*, is the control of humidity in the breeding houses. It must be maintained at a level high enough to keep the corn from becoming too dry, so that young *Sitotroga* larvae may enter the corn at all times, but not high enóugh to cause molding of the corn. This is not really difficult to accomplish, with proper construction of the houses, and without the costly devices of electric thermostatic control and suction or ventilating fans. Success in insect control on a commercial scale demands great economy, and one learns soon to eliminate costly equipment.

When the jar of newly parasitized eggs is removed from over the jar of corn, it is capped in a different manner from that described above. A disk of filter paper is shaped to conform with the mouth of jar by pressing the glass cover tightly over it. Removing cover, the paper is secured by stretching over it, encircling the mouth and gripping the filter paper just below the lip, one of the rubber bands supplied with the jars. This makes a cover permitting slight ventilation, and permeation of moisture but no escape of parasites. The jar in this condition is laid in a sufficiently warm place (27 to 29 degrees Centigrade) with bottom of jar toward the window to avoid escape of parasites in event that an accident may puncture the filter paper, and thus remains for the ensuing few days until adult wasps begin to issue.

Caution should always be observed in the matter of temperature and humidity, as *Trichogramma* wasps in the immature stages are very

sensitive to both. In a temperature maintained between the extremes of 26 degrees (night) and 31 degrees Centigrade (daytime), the strain of *Trichogramma* native to the coastal districts of Peru requires but 8 to 9 days to pass from egg to adult, yet a slight lowering of the mean temperature may result in lengthening the term of life cycle by several days. Excessive humidity is especially to be avoided in the close confinement of the glass jars, and is apt to result when too direct a source of light is used during the oviposition. It is almost sure to prove fatal to the wasps. In short, while the technique here described may be depended upon to serve admirably in *Trichogramma* propagation if properly handled, it is the little "tricks" in the game, which can be learned only by costly experience, that spell real success or failure. One should never lose sight of the fact that in *Trichogramma* he is dealing with an extremely delicate insect, and one very responsive to slight changes of temperature, humidity and light.

The advantages of the jar method as here described may be summed up as follows:

(1) A jar may contain up to a quarter of a million eggs, so that simplicity of handling, and advantage over petri dishes or egg cards, are evident.

(2) As Trix seek the light during activity, they are in constant contact with the eggs against the glass, and oviposition is not neglected, but made very easy.

(3) Eggs are thoroughly protected from contact with, or damage by any exterior object, as well as from undue variations of humidity.

(4) Parasitized eggs are easily counted without touching them by marking small rectangles with India ink on the outside of jar, then counting the proportions within the rectangles.

(5) Transfer of the Trix without loss from one jar to another is very easy by reason of the positive phototropism of the wasps.

(6) Jars are very durable, and loss from breakage is rare, unlike the petri dishes.

(7) Salvage of all the *Sitotroga* larvae from unparasitized eggs is facilitated.

(8) Release of the parasites is simplified. Walking down the windward side of a cane field with an open jar of parasites in each hand may release a very large number of wasps in a short space of time, without danger of their mortality from any source.

(9) There is no loss of "expendable property" except in an occasional renewing of the adhesive tape. Jars of exhausted eggs are

quickly washed and reused, so that six to eight dozen jars will handle all the eggs one can produce from a hundred bushels of corn.

(10) The jars of corn containing *Sitotroga* larvae salvaged from unparasitized eggs, when kept closed and intact, constitute a pure culture of the grain moth, and if set aside may be used for restocking the moth breeding rooms following any fumigation that may have been necessitated by an invasion of mites, weevils, or *Sitotroga* parasites. This eliminates the necessity of laying aside in refrigeration a quantity of *Sitotroga* eggs for the purpose, with its consequent curtailment of Trix production, and gains much time.

Since *Sitotroga* requires about 35 days to mature from the egg, one may keep on hand constantly (if sufficient jars are available) from 120 to 150 of these "pure culture" jars, capped with filter paper and rubber band, as they accumulate at the rate of 30 per week when parasitizing five jars of eggs daily. Only the jars in which moths have begun to issue need be dumped into the breeding rooms. Thus a pure culture regenerating stock of more than a million moths, in all stages of development, may be kept in constant readiness to meet any emergency.

SECOND REPORT ON THE EFFICIENCY OF BAIT TRAPS FOR THE ORIENTAL FRUIT MOTH[1] AS INDICATED BY THE RELEASE AND CAPTURE OF MARKED ADULTS

By L. F. Steiner, *Assistant Entomologist*, and W. P. Yetter, Jr., *Associate Entomologist, Fruit and Shade Tree Insect Investigations, U. S. Bureau of Entomology*

Abstract

Tests of bait-trap efficiency were continued at Cornelia, Ga., in 1932 by releasing large numbers of marked oriental fruit moths within baited and unbaited peach orchards. Of 1,144 released on 33 different days before peach harvest in a 16-acre orchard baited with 400 traps, 76.4 per cent were recovered; the females had deposited nearly 14 per cent of their eggs. Of 200 released before harvest in a 37-acre orchard baited with 2,200 traps, 89 per cent were recovered; the females had deposited 3.6 per cent of their eggs. Sixty to 80 per cent reductions in fruit injury were obtained in these orchards despite evident migration from more than 1,000 acres of surrounding unbaited orchards. After harvest the percentage of moths recovered from releases diminished, owing in some instances to migration

[1]*Grapholitha molesta* Busck.

out of the baited orchards before oviposition began. Of 492 moths released on 17 different days after peach harvest in the 37-acre orchard only 41 per cent were recaptured. The females had deposited 17.5 per cent of their eggs. An indication of the extent of interorchard movement was obtained by the release of 1,978 marked moths in unbaited peach orchards at distances varying from 75 yards to 1¾ miles from baited orchards. Sixteen flights of more than one-half mile and 100 of more than one-fifth mile occurred. Flights of 9,900, 9,400, 9,250, 7,250, 6,000, 5,900, and 5,300 feet were recorded, three of them before harvest, and four of them between baited orchards. The longest was by a female which deposited eggs after her capture. Releases made on four sides of the 37-acre baited orchard, one-fourth mile from the nearest traps, were followed by recoveries of 3.5 to 17 per cent. Releases made on two sides of the 16-acre orchard, one-eighth mile from the nearest traps, were followed by recoveries of 18.8 and 28.4 per cent. The experiments indicate that bait-trapping on a large scale, if properly conducted, should give satisfactory results Baiting on a smaller scale may eventually become practicable if more efficient baits can be developed. The recoveries were made by experimental baits mixed among each other. Many were almost useless. They maintained an average attractiveness 65 per cent less than the best in the 16-acre orchard and 40 per cent less than one of the best in the 37-acre orchard.

Previously reported experiments[2] in which marked oriental fruit moths were liberated in baited and unbaited peach orchards and captured again proved that migration between orchards was so extensive that the actual infestation reduction within treated orchards could not be taken as a full measurement of bait-trap efficiency.

Although the degree of control to be obtained within the area baited is of first importance, nevertheless the reduction obtained in adjacent unbaited orchards can not be ignored, especially since the evidence indicates that the fruit moth population in almost any orchard is a menace to other orchards in the vicinity whether or not they contain bait traps.

It is apparent, therefore, that efforts at artificial control must include large acreages to be most successful. With the completion of large-scale experiments with bait traps for the oriental fruit moth at Vincennes, Ind., and Cornelia, Ga., in 1931 and the inauguration of more intensive studies to develop new baits and increase our knowledge of the insect's habits, the value of the marked-moth release experiments increased. The investigations reported herein were conducted at Cornelia during 1932.

[2]W. P. Yetter, Jr., and L. F. Steiner. A Preliminary Report on Large-Scale Bait Trapping of the Oriental Fruit Moth in Indiana and Georgia. Jour Econ. Ent. 24: 1181–1197. 1931.

W. P. Yetter, Jr., and L. F. Steiner. Efficiency of Bait Traps for the Oriental Fruit Moth as Indicated by the Release and Capture of Marked Adults. Jour. Econ. Ent. 25: 106–115. 1932.

Methods of Experimentation

Marking of Adults.—The atomizer-dye method of marking the moths, as described in the previous report, was again utilized. Newly emerged adults were carefully sprayed with 1 per cent solutions of Spirit Violet or Spirit Blue or 1½ per cent solutions of Eosin or Brilliant Yellow, 95 per cent alcohol being used as the solvent. Too much of the dye solution was found to injure the moths, too little would not make all of them recognizable if recovered. All moths showing evidences of having been marked were brought to the laboratory for microscopical verification.

Determination of Egg Content.—The writers were assisted in the original studies concerning the egg content of oriental fruit moths by E. M. Livingstone and L. A. Zimmer at Cornelia in 1930 and 1931, respectively, and by E. C. Barr at Vincennes in 1931. Livingstone's examinations showed that few fully developed eggs began to appear before the second day and he found no evidence that oviposition occurred within 48 hours after emergence. Barr privately made more intensive studies than were possible in connection with his official duties and worked out the morphology of the reproductive organs of the female oriental fruit moth. He secured valuable data indicating that the recognizable egg content increased until 20 to 24 hours after emergence, at which time the moths contained their maximum number of immature eggs. He also found that fully developed eggs began to form in the ovarian tubes at this age in occasional moths.

In connection with the present investigations the writers dissected some 750 females for egg-content determination. Only those alive immediately before dissection were utilized, since it was found that after death and occasionally in aged moths there was a rapid breakdown of ovarian tissue, particularly at the tip of the vitellarium where the immature eggs are the smallest, which would thus make a reasonably accurate egg count impossible. In most instances the egg content as given is only approximate, for in tearing apart the tips of the ovarian tubes (normally four in each ovary) injury frequently resulted to the smaller eggs in one or more tubes. Usually the tubes each contain about equal numbers of eggs, especially before oviposition begins. The number in injured tubes was therefore estimated from the content of those which were not injured.

There is no evidence that additional immature eggs form after a moth reaches the age of 24 hours. It was found that low temperatures

delayed the formation of the first mature eggs and thus prolonged the preoviposition period. Females recovered from traps within 48 hours after their emergence were classified as preoviposition-period moths, since most of these fell into the traps during the evening hours when approximately 10 or 34 hours old. The most accurate egg counts can be made at this age. When the moths are older the condition of the ovarian tubes makes the smaller eggs difficult to recognize and some are missed. Egg deposition may therefore have been less in some instances than the egg counts indicated. The number of eggs deposited by the females before capture was estimated for each release by comparing the average number of eggs in all females with the average number in those captured during their preoviposition period.

In 1931 the preoviposition egg content averaged 141 per female, in 1932 approximately 200. The maximum number of eggs found in a female was 362. The greater egg content in 1932 is significant since it is probably one of the causes for the large infestation increase. Larger females usually contain more eggs, and with an abundant food supply larger individuals will be developed.

Types of Releases.—Releases were of three types, as follows:

Type A—A group of moths liberated at a single point at one time. In addition to the number recovered, it was possible to study the rate and direction of dispersal and the age at which the moths were captured.

Type B—Several groups of moths, similarly marked, liberated at the same point on successive days. Recoveries from such releases gave a more accurate indication of what the traps were accomplishing and made possible the use of more moths, but prevented any record of the time interval between release and capture except for those recovered within 24 hours after the first liberation.

Type C—Several groups of moths, similarly marked, liberated at different points within the same orchard on successive days. This type gave the most accurate indication of bait-trap efficiency within the orchard during definite periods, but made impossible a determination of the distances traveled or the age of the moths when captured, except for those recovered within 24 hours after the first release.

Points of Release.—Releases of 4,095 marked moths were made between May 4 and September 11, 1932. Of this number, 1,978 were liberated within nine unbaited peach orchards at distances of from 75 yards to 1¾ miles from the nearest traps, and 2,117 within three of the four baited or partially baited orchards described below.

The largest of the baited peach orchards called the Wade Area (Fig. 56), included 37 acres of Georgia Belle and Elberta and was bounded on all sides by unbaited peach and apple trees

It contained 2,200 traps, in which 47 different bait solutions were being tested Each tree in every second pair of rows contained a

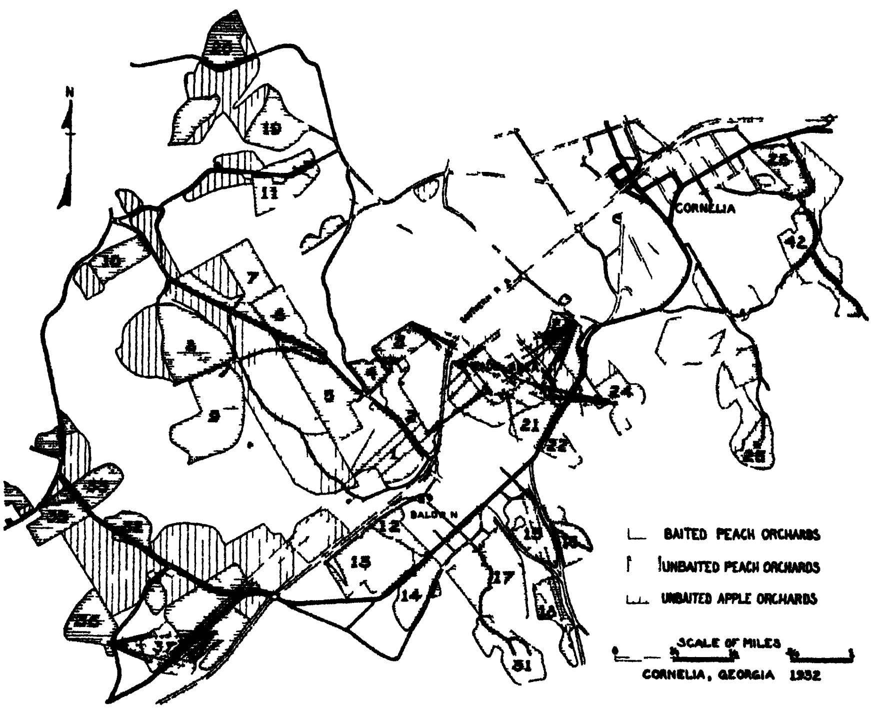

Fig 56—Experimental baits were tested in 1932 in the Wade Area, Orchard 37, Orchard 18, and Orchard 11 Points of release and capture for all inter-orchard flights originating within baited orchards or at points more than one-eighth mile from traps are indicated (In 1931 two moths flew more than 6,000 feet from Orchard 25 to the Wade Area)

trap of the wide-mouth, glass-jar, screen-covered type In a test area of this sort the average efficiency of the baits naturally was less than that of the better solutions which might be recommended for commercial use The 2,200 traps captured 37,614 unmarked moths after the cessation of spring-brood emergence, or an average of 17 per trap. Two hundred of the traps each contained 1 cubic centimeter of emulsified terpenyl acetate in a 10 per cent medium soft sugar solution used as a check bait; these captured an average of 27.4 moths per trap.

The second largest baited orchard, No. 37, also contained test baits that had an average efficiency much less than that of the check bait. This was a 16-acre Elberta orchard containing 400 traps, each tree in every fourth row being baited. These traps captured 17,843 unmarked moths, an average of 44.6 per trap, while the terpenyl acetate-medium soft sugar bait in this orchard averaged 127.7 per trap. No point in the orchard was more than 400 feet from an outside boundary.

Orchard 11, in which one release was made, contained 20 to 35 traps, which were being utilized to compare the relative efficiency at different ages of two very attractive baits. The traps were distributed in a single row, one to every second tree.

Orchard 18 was the fourth orchard baited. No moths were liberated there after 96 traps were placed in 24 of its trees.

Discussion of Results

Release Experiments in Baited Orchards.—The results of all releases made within baited orchards are summarized individually in Table 1, and collectively in Table 2. Brief supplementary notes on these releases follow:

Nos. 1–3. Weather fair. No. 1 was made in a quarter of the orchard baited with relatively unattractive granulated sugar-aromatic combinations. All recaptured moths flew into adjacent blocks where more attractive baits were located. Release No. 2 resulted in the first and only 100 per cent recovery. Eighty-nine per cent were recaptured within 48 hours.

No. 9. Weather fair until June 8, rainy from 8th to 19th. Again there was a definite movement of moths from the groups liberated among the granulated-sugar baits to the areas containing brown-sugar combinations.

Nos. 10–11. Showers during afternoon and evening occurred on 11 days during the recovery period. With an interchange of the two types of bait combinations between their areas the direction of moth movement was reversed, the moths flying into the new brown-sugar blocks.

No. 20. Weather warm and generally fair except for two rainy nights.

No. 21. Rain on all except three afternoons or evenings. Temperatures at dusk never less than 72°F.

No. 24. Made after harvest. Rain fell while three of the four groups of moths were being liberated. Three moths from this release were recaptured in the Wade Area, 1¾ miles northeast, after making minimum flights of 9,900, 9,400, and 9,250 feet. Two were females.

No. 13. Showers occurred at dusk or during the afternoon on all except three days of the recovery period. On June 21, 104 moths were liberated and on the 23rd, 96. Recoveries for the first four days, beginning June 22, were, respectively, 7, 50, 68, and 35 moths.

No. 22. Weather rainy. Release made near end of peach harvest.

No. 23. Showers daily from August 10 to 20. Twenty-five per cent of the recoveries were made among 17 per cent of the traps along the boundaries of the orchard. Most of these recoveries were along the short side adjacent to the young Hale orchard in which the "nubbin" crop was ripening.

No. 28. Weather fair. Captured moths well distributed over area.

Nos. 5, 6, 7, 8. Release of moths marked with four colors among 20 traps was followed in two hours by a severe windstorm, the average velocity exceeding 14 miles per hour and occasionally reaching 25 miles per hour, with some rain near dusk.

TABLE 1. RESULTS FROM RELEASES OF MARKED ORIENTAL FRUIT MOTHS IN BAITED ORCHARDS AT CORNELIA, GA., 1932

Release No.	Dates released	Release type	Orchard	Point of release	Number of moths released	Number of moths recovered: Males	Females	Total
1......	May 4	A	No. 37	Center	17	8	4	12
2....	May 5	A	No. 37	Center	28	19	9	28
2....	May 6	A	No. 37	NE. center	66	38	19	57
9....	May 30–June 10	C	No. 37	12 points	321	114	137	251
10....	June 16–18	C	No. 37	3 points	85	28	27	55
11....	June 19–23	C	No. 37	5 points	229	94	84	178
20....	July 13–19	C	No. 37	7 points	200	66	72	138
21....	July 25–27	C	No. 37	3 points	198	72	83	155
24....	Aug. 15–18	B	No. 37	Center	120	13	12	25
13....	June 21–23	B	Wade	Center	200	84	94	178
22....	July 28–29	B	Wade	N. center	58	14	19	33
23....	Aug. 8–13	C	Wade	6 points	200	39	37	76
26....	Aug. 31–Sept. 5	B	Wade	Near S. side	163	38	26	64
28....	Sept. 9–11	B	Wade	Center	71	15	14	29
5, 6, 7, 8	May 9	A	No. 11	Center	161	42	49	91

Release No.	Per cent of moths recovered	Day of last recovery[1]	Average number of eggs in— Pre-ovip.[2] females	All females	Maximum distance (feet) traveled	Average distance (feet) traveled by— All Moths	Males	Females
1.....	70.5	8th	186.0	169.2	375	204	146	318
2.....	100.0	11th	180.3	168.8	400	145	142	151
3.....	86.3	8th	192.8	174.2	550	122	117	131
9......	78.1	12th	192.2	169.9				
10.....	64.7	11th	205.8	128.8				
11.....	77.7	16th	205.8	163.5				
20.....	69.0	6th	192.0	176.7				
21.....	78.2	10th	229.2	199.2				
24.....	20.8	8th	([3])	180.4	9,900	1,322	928	1,747
13.....	89.0	7th	193.3	186.3	850	175	160	188
22.....	56.8	8th	232.8	195.6	1,125	455	385	506
23.....	38.0	11th	196.4	158.2	6,000			
26.....	39.2	9th	200.0	175.3	1,200	358	220	560
28.....	40.8	10th	([3])	171.8	725	270	158	391
5, 6, 7, 8	56.5	7th	192.9	176.7	480	115	118	111

[1]After last liberation.
[2]Moths dissected before they had oviposited.
[3]Not possible to determine.

TABLE 2. RECAPITULATION OF RESULTS FROM RELEASES OF MARKED ORIENTAL FRUIT MOTHS MADE IN THE TWO PRINCIPAL BAITED ORCHARDS AT CORNELIA, GA., IN 1932

Orchard and time interval	Release No.	Number of liberation points	Number of liberation days	Number of groups released	Number of moths released	Number of moths recovered: Males	Females	Total	Per cent of moths recovered
Orchard 37—									
Before harvest.....	1–3, 9–11, 20, 21	32	33	33	1,144	439	435	874	76.4
After harvest......	24	1	4	4	120	13	12	25	20.8
Entire season......	1–3, 9–11, 20, 21, 24	33	37	37	1,264	452	447	899	71.1
Wade Area—									
Before harvest.....	13	1	2	2	200	84	94	178	89.0
After harvest......	22, 23, 26, 28	9	17	17	492	106	96	202	41.0
Entire season	13, 22, 23, 26, 28	9	19	19	692	190	190	380	54.9

Orchard and time interval	Number of females dissected	Number of eggs found	Average number of eggs in: Preovip. females	All females	Max. distance (feet) traveled	Number of moths having distance records	Average distance (feet) traveled by: All moths	Males	Females
Orchard 37—									
Before harvest.....	373	64,437	200.1	172.7	550	97	138	128	160
After harvest......	9	1,624	([1])	180.4	9,900	25	1,322	928	1,747
Entire season......	382	66,061	([1])	172.9	9,900	122	381	261	593
Wade Area—									
Before harvest.....	71	13,237	193.3	186.4	850	178	175	160	188
After harvest......	62	10,823	211.5	174.5	6,000	127	407	325	502
Entire season......	133	24,060	199.0	180.9	6,000	305	272	233	309

[1]Unknown.

In orchard No. 37 before peach harvest the recoveries ranged from 64.7 to 100 per cent. As shown in Tables 1 and 2, 76.4 per cent of the 1,144 moths liberated between May 4 and July 27 were recaptured. These moths had been released in 33 groups on as many days at 32 locations within the orchard. They had deposited an average of not more than 28 eggs per female or 14 per cent of their total. After peach harvest extensive migration occurred and only 20.8 per cent were recovered from the one release made in this orchard during August.

In the Wade Area but one release was made before harvest. Of 200 moths, 89 per cent were recaptured. The females had deposited an average of seven eggs each or 3.6 per cent of their total. After harvest 41 per cent of the 492 moths liberated on 17 different days between July 28 and September 11 were recovered. Recoveries for individual releases ranged from 38 to 56.8 per cent. These females had deposited about 17.5 per cent of their eggs before capture.

Release Experiments in Unbaited Orchards.—The results obtained from individual releases made in unbaited orchards are summarized in Table 3. These releases indicate somewhat the attraction that baited orchards have for moths emerging in surrounding unbaited orchards, and prove the ability of the oriental fruit moth to fly long distances. The point of release and point of capture for all moths known to have flown more than one-eighth mile to baited orchards during 1932 is shown in Figure 56. This includes four flights of more than a mile between baited orchards, in addition to three of more than a mile from unbaited to baited areas. Brief supplementary notes on releases made in unbaited orchards follow:

No. 4. Weather fair. Release made before the Wade Area or Orchard 18 was baited. The nearest traps were in Orchard 37, 1¾ miles west.

No. 12. Male captured on the fourth day after last release. Preceding three days were rainy. Flight was to nearest traps, 1 mile north.

Nos. 14–17. Weather fair. Wind shifting but generally from northwest. Releases made during the same period one-fourth mile from the Wade Area in four directions. Orchard 23 in very poor condition. Flights of more than a mile were made in opposite directions by two males.

Nos. 18–19. Weather generally fair. Wind shifting. Releases made one-eighth mile from opposite sides of Orchard 37, No. 18 among young unbearing trees and No. 19 among young trees bearing a crop (very similar to conditions in Orchard 37).

No. 25. Weather fair. No recoveries. Release made 1½ miles south of traps in Orchard 11, same distance west of Wade Area, and north of Orchard 37.

No. 27. Release made in Hale orchard southwest of Wade Area during rainy weather. Growth conditions at point of release very superior to Wade Area.

TABLE 3. RESULTS FROM RELEASES OF MARKED ORIENTAL FRUIT MOTHS IN UNBAITED PEACH ORCHARDS, CORNELIA, GA., 1932

Release No.	Date released	Release type	Points of release	Number of moths released	Number of moths recovered: Males	Females	Total
4	May 7–8	B	S. end Orch. 18	350	0	0	0
12	June 20, 22, 24	B	Center Orch. 18	375	1	0	1
14	July 8–12	B	Orchard 23	200	14	20	34
15	July 8–12	B	Orchard 24	200	6	4	10
16	July 8–12	B	Orchard 2	200	3	4	7
17	July 8–12	B	Orchard 3	200	7	5	12
18	July 13–14	B	1/8 mi. NE. of Orch. 37	88	18	7	25
19	July 13–14	B	1/8 mi. W. of Orch. 37	85	8	8	16
25	Aug. 19–24	B	Orchard 9	117	0	0	0
27	Aug. 31–Sept. 5	B	75 yds. SW. of Wade A.	163	16	3	19

Release No.	Per cent of moths recovered	Day of last recovery	Average egg content (number)	Maximum distance traveled: Feet	Direction	Average distance (feet) traveled by—: All moths	Males	Females
12	0.2	4th		5,900	N.		5,900	
14	17.0	13th	203.0	7,250	NW.	1,973	2,384	1,685
15	5.0	9th	130.0	3,200	W.	2,037	2,877	1,655
16	3.5	6th	171.2	5,300	SE.	2,452	3,006	2,037
17	6.0	6th	178.4	3,150	SE.	1,958	2,247	1,554
18	28.4	11th	188.8	1,400	SW.	1,075	1,058	1,117
19	18.8	9th	165.1	1,700	E.SE.	1,240	1,281	1,200
27	11.6	7th	304.0	1,450	E.	647	525	1,300

FACTORS AFFECTING MIGRATION AND BAIT TRAP EFFICIENCY

METEOROLOGICAL CONDITIONS. — Wind direction appeared to have little effect on direction of flight within baited orchards. Because of the length of some flights into baited orchards, the impossibility of determining the exact route followed or the elevation at which the flight was made, and because wind direction at tree-top level was not always the same at the different points under observation, the effect of wind direction on long flights could not be ascertained. However, if made at tree-top level most of them were against or across the wind.

Bait traps can function only while the adults are active. Activity is most affected by light intensity, with the optimum conditions prevailing during the hour at dusk and the hour at dawn. In these two periods nearly 75 per cent of the moths were captured, and most of the others entered the traps immediately before or after these hours. If certain weather conditions, such as rain, wind velocities in excess

of 10 miles per hour, or temperatures below 60°F., occur at these times, activity for the entire day may sometimes be prevented. Complete darkness and bright sunlight, except on rare occasions, will prevent activity. Warm moonlight nights and dull cloudy days may permit it. Low temperatures which prolong the preoviposition period but do not entirely prevent activity give the traps a longer period in which to capture the moths before oviposition begins. The prevention of activity by weather conditions other than low temperatures is likely to force an accumulation of fully developed eggs in the females, with the result that more of them may be deposited before the moths react to the baits. Females have been observed to alight on a leaf, oviposit, and fly away in two seconds, and in captivity one female has deposited as many as 40 eggs in one-half day.

Environmental Conditions.—The percentage of moths recovered from releases was reduced somewhat as a result of mortality from unfavorable weather conditions, the actions of predatory insects, and injury from the dyes. Evidence indicates that it was also reduced by moth migration out of the baited areas. At the same time there was a replacement of emigrating moths by others attracted into the area to the traps, so that the proportion of ovipositing females captured should be greater than the recoveries indicate, especially late in the season.

During the forepart of the season, when new twig growth and developing fruit was abundant, no known flights between baited areas occurred, flights within baited orchards were relatively short, and a large proportion of the marked moths were recaptured near the points of release during the preoviposition period. Furthermore, the distribution of native moth captures over the orchards was uniform, egg deposition before capture was comparatively slight, and the efficiency of the bait traps apparently very high.

Twigs were hardening as the fruit began to ripen. No change in adult behavior, as indicated by the recovery experiments, occurred until Release No. 22 was made in the Wade Area when harvest was about completed. Before the recoveries from this ceased the only fruit remaining in the vicinity of the orchard was the Hale "nubbin" crop adjacent to, and southwest of, the baited block. The 56.8 per cent recovery from Release No. 22 was lower than from any made in the two large baited orchards until that time but higher than any made after harvest. Immediately after harvest interorchard movement became more extensive.

The long-distance flights from Orchard 23 to Orchard 11, from the Wade Area and Orchard 2 to Orchard 18, and from Orchards 18 and 37 to the Wade Area indicate that conditions at the point of origin were not attractive enough to hold all the moths during their preoviposition period. Their subsequent recapture in areas supposedly less attractive in some instance than those they left suggests that their flights were originally stimulated by something other than the odors from the areas they were captured in, but that their responses to these stimuli changed after they passed through their preoviposition period. In the case of one moth the flight of 7,250 feet to Orchard 11 (which had only 30 traps) was made before harvest from an unbearing orchard making poor growth to a bearing orchard in very good condition. The fact that Orchard 23 was in poorer condition than Orchards 2, 3, and 24 may account for the greater recovery in the Wade Area from Release No. 14 than was obtained from Releases 15, 16, and 17. Likewise more migration occurred from Release No. 18 to Orchard 37 than from Release 19, possibly because the former was made in an unbearing orchard. After harvest a flight was made, from the Wade Area, 6,000 feet south to Orchard 18, which had less than 5 per cent as many traps and was in no better condition. At about the same time the three flights of 9,900, 9,400, and 9,250 feet were made to the Wade Area from Orchard 37. In the latter orchard growth conditions were much superior to the Wade Area but inferior to conditions in some of the intervening orchards. The longest of these flights was made by a female which, after capture, was confined in an oviposition jar where it deposited 14 eggs before becoming too weak to continue. Upon dissection it was found to contain 99 additional eggs.

During August, before removal of the Hale "nubbin" crop adjacent to the Wade Area, there was a definite movement of marked moths to that side of the orchard. Likewise the native population, as evidenced by location of the captures, concentrated there. Immediately after removal of the "nubbins" this movement ceased and distribution of the catches became more uniform. Incidentally, the removal of the 1932 crop at harvest was thorough, so that little or no fruit remained in the orchards.

After harvest fewer moths were captured during their preoviposition period, and movement within baited orchards averaged twice as far as before harvest.

Usually within baited orchards the females flew farther than the

males but in migration to baited orchards the males averaged the greater distances. Recoveries from releases made more than one-eighth mile from traps in unbaited areas (Fig. 56) were uniformly distributed over baited blocks, suggesting that these flights were more or less continuous or were made at a higher elevation, in contrast to flights from near-by releases which more frequently end as soon as the moths reach the edge of the area baited. Incidentally, in the Wade Area 9 per cent of the traps contained the terpenyl acetate-medium soft sugar bait and captured 17 per cent of the 84 marked moths attracted from outside the area.

The behavior of the moths both before and after harvest indicates that in the absence of fruit or succulent twigs there is a more than normal migration within two or three days after emergence and before the reaction to bait odors and the urge to oviposit become pronounced. It can not be prevented by the baits now in use, although it appears that when the moths begin ovipositing some may be attracted back to the orchard from which they migrated. The attraction by apple orchards probably increases adult movement after peach harvest, although the three longest flights between Orchard 37 and the Wade Area must have been made over the mile and a quarter of unbaited peach and apple trees between.

Fruit Moth Injury in Baited and Unbaited Orchards

It was not possible to secure accurate records of fruit injury during the 1932 season. The external examination of nearly 24,000 fruits, however, provided approximate figures which are of interest.

An extremely light crop of Elberta in the Wade Area averaged 12.3 per cent visible wormy fruit, while a crop averaging four times as large per tree in the unbaited orchards was 31.6 per cent wormy. The ratio of worm entrances in fruit per tree between the two areas was approximately 1 to 10. The fruit in Orchard 37 was also 12.3 per cent wormy, although during 1930 and 1931 this was one of the most severely infested of the unbaited orchards. A normal crop of Georgia Belle in the Wade Area was 1.8 per cent wormy as compared to 10.3 per cent for Belle in unbaited orchards.

The Wade Area was not baited until after spring-brood emergence had ceased. In 1931[1] its Elberta fruit was 0.5 per cent wormy, after the orchard had been baited, as compared to nearly 5 per cent injury to fruit in unbaited orchards, yet in 1932 the first-brood larval damage to twigs with one exception was greater than in any of the nine or-

chards with which it was compared. This can be accounted for only by a movement of spring-brood moths into the area where twig growth, at that time, was more succulent than in adjoining orchards. Despite this and the extensive migration into baited areas, as evidenced by the release experiments, the percentage of wormy fruit in the two principal bated orchards was less in 1932 than in any one of the 12 unbaited orchards in which fruit infestation records were secured. As further evidence that interorchard movement tends to equalize the moth distribution over a considerable area, the orchards baited in 1931 but not baited in 1932 and those unbaited both seasons averaged 32.8 and 30.9 per cent wormy fruit, respectively. The infestation ratio between the same orchards in 1931 was 1 to 9.3. Likewise the orchards in which twig injury made the most marked increases were those which had been baited in 1930 and 1931 and left unbaited in 1932. The increase over 1931 was 5.9 times, as compared to 2.3 times in those never baited. There was practically no increase in twig growth in either group.

Conclusion

The release of 1,144 marked oriental fruit moths on 33 different days before harvest in a 16-acre orchard baited with 400 traps indicated that these traps were capturing 76 per cent of the emerging adults. Before capture the female moths had deposited nearly 14 per cent of their eggs. There was an apparent reduction in wormy fruit of not less than 60 per cent as a result of the bait-trapping despite the use of baits which captured an average of only 35 per cent as many moths per trap as the best tested in the orchard, and despite extensive migration from adjacent orchards into this small area. The release of 200 marked moths before harvest in a 37-acre orchard baited with 2,200 traps indicated that as high as 89 per cent of the moths were being captured, and after harvest the release of 492 moths on 17 different days indicated that the baits were capturing 41 per cent of those emerging in the area during this period. Previous to harvest the recaptured moths had deposited 3.6 per cent of their eggs, after harvest, 17.5 per cent, before they were caught.

It appears that the use of one trap per two trees permits less oviposition before capture than the use of one trap to four trees. The reduction in fruit injury in the larger baited orchard was greater than in the smaller one.

The release of 1,978 marked moths in unbaited orchards proved that migration to baited or between baited orchards was extensive. Other evidence indicates that it is extensive between unbaited orchards and that the absence of fruit or succulent twig growth stimulates flight during the preoviposition period to other areas. Seven flights ranging between 1 and nearly 2 miles were recorded during 1932. A female which had flown a minimum distance of 9,900 feet deposited eggs after capture. This flight was made between two baited orchards. One hundred flights of more than one-fifth mile and sixteen of more than one-half mile were made. The four baited orchards, of which approximately 60 acres contained traps, very probably attracted moths from more than 1,000 acres of peach trees, since this acreage is located within one mile of one or more of them. For the same reason the number of moths migrating into the baited orchards may have been greater than the native population.

Large-scale bait-trapping should give satisfactory results. Baiting on a smaller scale may eventually become practicable if more efficient baits can be developed. At present, large-scale operations, using approximately 50 traps per acre or one per two trees, should not cost more than $7.25 per acre for the season at Cornelia. The development of more efficient baits which will make possible the use of fewer traps per acre will reduce this cost.

ORIENTAL FRUIT MOTH PARASITES IN MICHIGAN[1]

By J. M. MERRITT,[2] *Section of Entomology, Michigan State College*

ABSTRACT

A report on the activity of the native parasites of *Grapholitha molesta* Busck in Michigan orchards since 1929. Data are presented showing an average parasitism of 30 per cent for a period of three years. Twenty-one species of parasites have been reared, 82 per cent of which were *Glypta rufiscutellaris* Cress. Considerable seasonal variation in the fruit moth population is shown, apparently not closely correlated with the activity of the parasites.

The oriental fruit moth, *Grapholitha molesta*, Busck, was first reported in Michigan the fall of 1928 from a commercial peach orchard

[1]Journal Article No. 133 (N. S.) from the Mich. Agr. Exp. Sta.

[2]Experimental work in control of the fruit moth was begun in 1929 under the supervision of L. G. Gentner, Research Assistant in Entomology, and subsequently continued under the supervision of Ray Hutson, Associate in Research in Entomology.

in Washtenaw county. The following year experimental work was started in that orchard on the control of the pests. The appearance of parasitism in this orchard, as shown by rearing and field observation, indicated that native parasites might be of importance in the early development of an infestation.

Beginning in 1930 regular collections of twigs injured by the fruit moth were made in a nearby orchard which was severely infested. The twigs were caged in the field insectary and the larvae allowed to complete their development on apples. Daily recoveries of parasites were made as soon as they started to emerge. This procedure supplied data on the prevalence of the fruit moth in the orchard, as well as on the parasites.

In 1932 the procedure was extended to include another orchard, in which the infestation had become large enough to permit practical study.

Through the kindness of R. A. Cushman and C. F. W. Muesebeck of the United States National Museum, final identification of all parasites has been made, with the exception of the *Glypta rufiscutellaris* Cress., collected in 1932.

During the season of 1929, the following six species of parasites were reared, for the most part, from cocoons collected on the trees: *Aenoplex betulaecola* Ashmead, *Cryptus alacris* Cresson, *Ephialtes aequalis* Prov., *Hoplocryptus incertulus* Cushman, *Idecthis nigrocoxalis* Cushman and *Dibrachys boucheanus* Ratz.

Summarized data on the relative abundance and importance of the fifteen different species reared during 1930, 1931, and 1932 are presented in the following tabulation:

These data show that *Glypta rufiscutellaris* Cresson, has been the most important parasite reared, oven 80 per cent of all parasites being of this species. *Cremastus minor* Cushman was somewhat active in 1931, while recoveries of *Pristomerus ocellatus* Cushman, and *Dioctes obliteratus* Cresson were more common than has usually been reported. Several other species were active at certain times, but the variation in their activity from year to year was considerable.

Glypta rufiscutellaris has shown the least variation in its seasonal activity. This species has consistently been recovered from the larval collections made in the first part of the second generation of the fruit moth, varying from the 1st to the 15th of July. The peak of parasitism has occurred during this generation, about the last of July, except in 1931, when parasitism of the third brood approached 75 per cent. The

Oriental Fruit Moth Parasites—Relative Abundance and Efficiency in Washtenaw County, Michigan, During the Period 1929 to 1932

Species of parasites	1930 Number of individuals emerged	1930 Percentage of larvae parasitized	1930 Percentage of all parasites	1931 Number of individuals emerged	1931 Percentage of larvae parasitized	1931 Percentage of all parasites	1932 Number of individuals emerged	1932 Per centage of larvae parasitized	1932 Percentage of all parasites	Average Number of individuals emerged	Average Per centage of larvae parasitized	Average Percentage of all parasites
Glypta rufiscutellaris Cress.	17	6.8	68.0	149	23.1	73.0	448	29.2	90.1	614	25.2	82.1
Cremastus minor Cush.				45	7.0	22.1	2	0.1	0.4	47	1.9	6.3
Pristomerus ocellatus Cush.							13	0.8	2.6	13	0.5	1.7
Cremastus forbesii Weed.				6	0.9	2.9	6	0.4	1.2	12	0.5	1.6
Macrocentrus delicatus Cress.	5	2.0	20.0				5	0.3	1.0	10	0.4	1.3
Diocles obliteratus Cress.	1	0.4	4.0	2	0.3	1.0	7	0.5	1.4	10	0.4	1.3
Ascogaster carpocapsae Vier.				1	0.15	0.5	4	0.26	0.8	5	0.2	0.7
Bassus cinctus Cress.							1	0.07	0.2	1	0.04	0.13
Calliephialtes grapholithae Cress.							1	0.07	0.2	1	0.04	0.13
Cremastus tortricidis Cush.							2	0.14	0.4	2	0.08	0.26
Epiurus indagator Cress.	1	0.4	4.0							1	0.04	0.13
Macrocentrus ancylivorus Roh.				1	0.15	0.5				1	0.04	0.13
Meteorus trachynotus Vier.	1	0.4								1	0.04	0.13
Microbracon gelechiae Ashm.							*5	0.07	1.0	*5	0.04	1.3
Microbracon mellitor Say.							3	0.2	0.6	3	0.12	0.4
All other parasites (1929)										22	0.9	2.9
Parasitism of larvae by all species	25	10.0	100.0	204	31.6	100.0	497	32.11	100.0	748	30.44	100.0
Number of fruit moth larvae	251			646			1,537			2,434		

*These parasites emerged from one fruit moth cocoon.

parasitism of the first generation has been slight except in 1931, when parasitism by *Cremastus minor* was approximately 20 per cent.

A study of the larval population of the fruit moth in this orchard for the same three seasons indicates that the second generation has been considerably larger than the first, and that after the second generation there has been a great decrease in the larval population, with the result that the fruit infestation has been uniformly low; in fact, it has never reached 2 per cent. This decrease in population has coincided with the increase in activity of the parasites, but apparently cannot be attributed wholly to their effect, for the percentage of parasitism of the second generation has never been great enough to warrant the resulting decrease in larval population. In 1931 the parasitism of the second generation was 18 per cent, and the reduction in the orchard population of the fruit moth was 76 per cent from the second to the third generations, while in 1932 the corresponding figures were 12½ per cent and 75 per cent. Therefore, in this orchard, factors inhibiting the development of the fruit moth have in part made possible the high percentage of parasitism, which has occurred during the latter part of the season.

The results obtained during the summer of 1932 from another orchard are of interest in this respect: The infestation in this orchard of 150 acres had been slowly developing since the fall of 1929, the young, thrifty trees making conditions very favorable. The first brood was large in 1932, and as *Glypta rufiscutellaris* Cress. had been reared from collections made in this orchard in 1931, the parasite was expected to develop rapidly under the favorable host conditions. However, no recoveries of parasites were made until the second generation of the moth appeared. The second brood tripled the larval population, and during this period the parasitism increased to 34 per cent, nearly all by *Glypta rufiscutellaris*. The fruit moth population continued to increase and caused serious injury to the fruit, in contrast to conditions in the other orchard.

In spite of the increase in the larval population, parasitism had practically ceased at the end of the second brood. Large collections of injured twigs were made in the orchard, coincident with the emergence period of the parasites of the second brood. These collections indicated that the parasitism was negligible, and that several species were responsible. Apparently factors other than the prevalence of host material govern the activity of *Glypta rufiscutellaris* after the second brood of the fruit moth.

Summarizing these data, it may be said that the native parasites of the

fruit moth, particularly *Glypta rufiscutellaris* Cress., have been active to a considerable extent in Michigan since the introduction of the pest. All species combined have averaged a parasitism of 30 per cent for the last three years. It should also be evident that until more data are available on the factors governing the parasite-host relationships affecting their seasonal activity, probably little can be done in evaluating their economic importance.

EFFECT OF DUSTS ON THE ORIENTAL ROACH

By George L. Hockenyos[1]

ABSTRACT

A technique is described which was used to determine if very fine dust would enter the tracheae of the Oriental Roach (*Blatta orientalis*) Neither submergence in a dust nor suspension in a dust charged atmosphere caused dust particles to enter the tracheae. It is suggested that loss of moisture might account for the injurious effect of dusts on some insects.

There are numerous references in the literature of insect control to the possibility of inert dusts effecting the destruction of certain species of insects by a mechanical clogging of the spiracles. The following experiments were an attempt to determine if such a phenomenon could be observed with the Oriental roach (*Blatta orientalis*).

Individual roaches were stuck fast in an inverted position by means of paraffine. This was easily accomplished by putting a few drops of molten paraffine on the small end of a cork stopper. The dorsal surface of the thorax was then pressed into the paraffine and cold water poured over the insect to quickly harden the paraffine. Specimens so prepared could be readily examined under a binocular to measure the opening and observe the action of the thoracic spiracles. That this means of handling them was not injurious was evidenced by the fact that some were kept so implanted for three days without apparent injury. Observed in this way, the thoracic spiracles are seen to be protected by a flap-like valve which can open to give an unobstructed entrance into the spiracles or can be closed tightly. In the observed cases of respiration, the valve actually opened only a small part of its possible extension. Accurate measurement of the opening is difficult, but it may be said that a clearance of from 25 to 50 microns occurred in the observed operation of

[1]Contribution No. 156 from the Department of Entomology, University of Illinois. By Geo. L. Hockenyos.

the valve; and when turned back by a dissecting needle point the opening exceeds 200 microns. The larger trachea in the thoracic region measure approximately 250 microns in diameter in an adult Oriental roach. The abdominal spiracles are so depressed between the edges of the sternites and pleurites that no satisfactory measurements were obtained.

A sample of pure magnesium carbonate was obtained and found to consist chiefly of particles from 1 to 10 microns in size. A pint fruit jar was half filled with this material and five Oriental roaches placed therein. The jar was slowly tumbled for ten minutes so that the roaches were kept completely submerged. They were then removed to a large jar for observation. Their movements were considerably slower than those of some control roaches, but they were all alive at the end of 54 hours. Two specimens were then killed and the thoracic spiracles examined. There was no evidence of obstruction even though the dust had adhered to all parts of the body. The insects were dissected and the larger thoracic trachea examined microscopically. No evidence of dust particles could be found.

It was noted in dissecting these specimens that they had become so desiccated that there was no free body fluid. This condition could easily account for the relative inactivity of the insects and might be attributed to the action of the magnesium carbonate in absorbing and evaporating the body moisture.

A special dusting machine was constructed as follows: A series of tin pipes each 30 inches long and of 4 sizes, namely, 2 inches, 4 inches, 9 inches, and 30 inches in diameter, were arranged vertically on a common axis with the smallest on the bottom and the largest on the top. They were connected tightly and a piece of heavy piano felt stretched over the top of the uppermost pipe.

Ten roaches were placed in a screen cage and suspended in the center of the largest pipe. After the felt was put into place, a stream of air carrying magnesium carbonate dust was blown into the small pipe at the bottom of the vertical series of pipes. As the air stream expanded through the successively larger pipes, its velocity decreased and successively smaller particles of the carbonate were deposited on the shoulders where each pipe expanded into the larger one above. The felt retained practically all of the dust particles, and by lifting a corner of this covering momentarily it could be seen that the largest pipe was filled with an extremely dense atmosphere of very fine dust particles. These particles were collected on a microscope slide and found to measure from 1 to 4 microns in diameter.

The roaches were left in this machine for two hours while a slow stream of air charged with dust was blown in at the bottom. When removed from the machine they were observed to be covered with a very light coating of dust particles but seemed quite active. One of the ten was killed and dissected as soon as removed from the dusting machine, but no dust particles were found in the trachea. The other nine were kept under observation for three days and seemed quite as active as the controls.

Ten roaches were similarly treated in the dusting machine, but a clay dust containing 10% derris resin was used and the time of dusting reduced to 20 minutes, after which the roaches were individually freed from as much dust as possible by means of an air blast and soft brush. This latter precaution was taken to prevent their possibly ingesting enough derris from the antennae or legs to cause death. These insects seemed unaffected at the end of two days and the experiment was discontinued.

The evidence of these three tests would indicate that in the case of the Oriental roach dust particles even of very small size do not enter the thoracic spiracles, and the derris dust must not have entered any of the spiracles. Such injury as results from very heavy dusting is probably due to the desiccating action of the dust, since heavily dusted specimens suffered great loss of body moisture as compared to controls.

THE NEW MEXICO RANGE CATERPILLAR AND ITS NATURAL CONTROL

By V. L. Wildermuth, *Senior Entomologist*, and J. C. Frankenfeld, *Associate Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology, U. S. Dept. of Agriculture*

Abstract

The New Mexico range caterpillar, *Hemileuca oliviae* Ckll., after approximately 12 years of restricted activities, has again reached damaging numbers and has spread over the entire cattle-range area of northeastern New Mexico. Control is being attempted through breeding and colonizing its native egg parasite.

A study of the rise and fall in abundance of the New Mexico range caterpillar, *Hemileuca oliviae* Ckll., is of special interest as a striking example of the interrelation of insects and their enemies. The range caterpillar is confined to an area located mostly in northeastern New Mexico, where it feeds on the range grasses. The center of infestation includes the five northeastern counties of the State and embraces a

district having its extreme outside limits about 200 miles apart. Adults have been taken in southern Colorado and northwestern Texas, and larvae have been observed in the Panhandle district of Texas. Its past history is somewhat vague, but there are excellent grounds for believing that it has been a pest in northeastern New Mexico since that part of the country was settled in the last century.

The insect occurs in abundance over a period of approximately 10 to 12 years, after which it seems to be practically absent for a period of approximately the same number of years. Information furnished by ranch owners and others has revealed the fact that there was an outbreak from 1885 to 1895, with the peak probably occurring about the year 1892. This outbreak was apparently not brought to the attention of entomologists. Two outbreaks have been observed by entomologists of the U. S. Department of Agriculture. The first of these was reported to the Department in 1908. It had doubtless been in progress for a period of three or four years before it was reported, and it persisted until 1916, when the caterpillars became so reduced in numbers as to remain unnoticed for a period of about 10 years. The second is the present outbreak, which began in 1926. During the summer of that year a limited number of caterpillars were noted in an area of only a few square miles near Wagonmound, N. Mex., but they probably occurred in other isolated areas. The insect gradually spread from such areas until the past season (1932), when the caterpillar again seemed to be approaching its peak of infestation and was found distributed over practically the entire district. In many places they were extremely numerous while in others they occurred in limited numbers or were entirely absent.

The development of the caterpillars in large numbers over a wide area in the present outbreak has been influenced by climatic conditions that have tended to delay the peak of infestation. In the fall of 1929, caterpillars occurred in extremely large numbers in many places and it was predicted that the following year would witness a rather widespread outbreak. However, when these heavily infested territories were visited in May, 1930, it was observed that many eggs were late in hatching. Subsequently it was noted that a large majority of these eggs failed to hatch. It was first thought that this was due to the eggs having been killed by freezing during the previous extremely dry, cold winter, but observations made in subsequent years proved this surmise to be incorrect. Other observations have brought us to believe that this lack of hatching was due entirely to the infertility of the eggs. The cause of this condition has not been definitely decided but was likely due to

weather conditions at the time the moths were emerging in the previous fall. A snowfall approaching blizzard proportions accompanied by low temperatures prevented the mating of the moths. The males, having to a large extent issued from their cocoons preceding the females, were mostly dead by the time the weather moderated, and it is thought that many of the females thus oviposited without having been fertilized. The fertile eggs hatched extremely late in the summer of 1930, owing to dry conditions on the range. When sufficient rain fell for their hatching, the season was far advanced and, food being scarce, owing to a short growth of range grasses, the caterpillars did not reach a full-fed development at pupation. Female moths developing from these pupae were extremely low in vitality and consequently laid a smaller number of eggs, thus further retarding the multiplication of the insect to damaging numbers. Only this year, therefore, has it reached a wide distribution.

As has been mentioned, the outbreak of 1904 to 1916 was first brought to the attention of the Department of Agriculture in August, 1908. C. N. Ainslie carried to completion a thorough preliminary study of the life history of the caterpillar during the season of 1909, and a report of this study was subsequently published (1). In 1912, cattlemen in the district, being greatly alarmed at the widespread devastation caused to range grasses by the caterpillars, were instrumental in securing funds for detailed investigation and the possible control of the pest. These investigations were subsequently carried on from 1913 to 1916 by the senior author assisted by D. J. Caffrey and others (3). The work extended over a period of four years and, as previously mentioned, at the end of this time insufficient caterpillars remained to permit the continuation of the study.

The question naturally arises, Why does this insect become so extremely numerous and devastating and then suddenly wane in numbers so that one has to search for days and days before any caterpillars can be found? The answer to this is, Natural enemies, the chief of which, in 1916, was an egg parasite, *Anastatus samiflavidus* Gahan (2). This hymenopterous parasite was first noticed in the egg collections of 1913 at Koehler, New Mexico. Mr. Ainslie, in his studies in 1909, did not observe egg parasites and expressed great surprise when told that this species had been found. It seems quite likely that when Mr. Ainslie was making his study the parasite was present in only limited numbers, in isolated areas where it had maintained itself, and that it began its spread from these areas and was gradually increasing when first found

in 1913. Subsequently it developed in ever-increasing numbers until 1916, when eggs laid by the range caterpillar were found to be nearly 100 per cent parasitized by this interesting and valuable parasite. The apparent disappearance of the caterpillars on the open range in the following years is doubtless explicable in this manner.

Other natural enemies have been noted to assist in controlling this pest. Among the insect-control factors are two tachinids, *Tachina mella* Walk. and *Phorocera claripennis* Macq., which prey upon the larva; and two species of Hymenoptera, *Pimpla conquisitor* Say and *Chalcis ovata* Say, both of which parasitize the pupal stage of the caterpillar. Native beetles were also noted feeding upon both larva and pupa; the most conspicuous of these was *Calosoma obsoleta* Say. Other insect enemies of the pest, of minor importance, were encountered but it is unnecessary to mention them here since they have already been noted in former publications. Skunks were found to feed abundantly upon the pupae in many localities and exerted a considerable influence in reducing the numbers of the insects.

The range caterpillar was observed to return in damaging numbers in the summer of 1926, and it was noted during the years following that the pest was appearing each season in ever-increasing numbers. This led the Congress to put at the disposal of the Department of Agriculture a fund for investigating the control of the pest. Soon thereafter the senior author, in consultation with W. H. Larrimer, in charge of the Division of Cereal and Forage Insects, Bureau of Entomology, began the formulation of plans for attempted control.

In the investigation of 1913 to 1916 stress had been placed upon the introduction of parasitic or predacious insects as a possible means of control. Our efforts were concentrated quite largely on the introduction of the dipteron *Compsilura concinnata* Meig. and of three predacious beetles, *Calosoma sycophanta* L., *C. lugubre* Lec., and *C. calidum* Fab. The most promising of these beetles, *Calosoma sycophanta* L., was reared and distributed in large numbers. These insects, as is well known, had been of great value in assisting in the control of the brown-tail moth, *Nygmia phaeorrhoea* Don., and the gypsy moth, *Porthetria dispar* L., in Massachusetts and it was hoped that they might be of similar value against the range caterpillar. These were bred, reared, and released in large numbers, but observations showed that they had exerted only a minor influence in the control of the caterpillars. Knowing that the outbreak was finally terminated by the activities of the egg parasite, *Anastatus semiflavidus* Gahan, we now decided that a

promising control measure would be the artificial rearing and colonization of this insect. This egg parasite, after reducing the numbers of the range caterpillar, naturally itself becomes reduced to an almost negligible minimum. The caterpillars and parasites both seem to maintain their existence in small numbers in remote, out-of-the-way places in the range caterpillar territory. It was realized that the rise in abundance of the moths and their spread over a larger district occurs several years in advance of the increase in abundance of the egg parasite. Therefore it was argued that if we could find a few of these egg parasite in isolated spots, rear them in numbers, and colonize them at well-located points throughout the infested territory we could thus accelerate the speed of multiplication of the parasite and greatly reduce the period of years required for it to gain control of the range caterpillar.

The work was therefore begun and after much search we finally found eggs in the vicinity of Roy, N. Mex., that gave us 1.6 per cent parasitism. These eggs were taken to the U. S. Entomological Laboratory at Tempe, Ariz., and there, in a temperature-control chamber, the parasites were reared. From this small beginning, abundant rearings of the parasite were rapidly made and these have been distributed on the range caterpillar territory during the last two years. It remains for J. C. Frankenfeld and O. L. Barnes to discuss, in the paper that follows, the methods used in rearing this parasite.

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THE EQUIPMENT AND METHODS USED IN REARING THE NEW MEXICO RANGE CATERPILLAR PARASITE, *ANASTATUS SEMIFLAVIDUS* GAHAN

By J. C. Frankenfeld and O. L. Barnes, *Division of Cereal and Forage Insects, Bureau of Entomology, United States Department of Agriculture*

Abstract

This article contains a detailed description of the equipment and methods used in rearing and handling *Anastatus semiflavidus* Gahan under controlled conditions of temperature and moisture Descriptions include a constant-temperature room, incubators, refrigerators, and oviposition cages.

When studies were begun early in 1930 at the Tempe, Ariz., laboratory on the control of the New Mexico range caterpillar, *Hemileuca oliviae* Ckll., by its egg parasite, *Anastatus semiflavidus* Gahan, it was deemed advisable to begin mass production of the parasite as quickly as practicable. Because of the extremely long, hot summers in southern Arizona and the probable desirability of a practically uniform temperature, the year round, for the breeding and rearing of the parasite, it was agreed that a constant-temperature room should be constructed and equipped. Accordingly, the room was built during the spring of 1930, and the heating and cooling systems were installed and in operation before the end of that year.

The constant-temperature room is a few feet to the rear of the laboratory building proper. It is 14 feet long by 9 feet wide by 6 feet 5 inches high, inside dimensions. A double wall containing an intervening 6-inch layer of pine sawdust surrounds the room. The same construction is used in the ceiling, while the floor is of one layer of 1-inch pine flooring. Pine ceiling material is used throughout with the exception of the floor and the outer overhead wooden layer, the latter being of 1 by 12 inch pine lumber. The entire room is covered by a gable-type roof of wooden shingles. The room may be entered through double wooden doors (inner and outer) 2 feet 6 inches by 6 feet in size. There is an air space of 3 inches between the inner and outer doors. The outer wall extends to the ground level, and the floor is about 4 inches above this level. The room is ventilated by means of a vent, 4¾ inches by 4¾ inches in size, located in the center of the top of the room, and by two openings in the floor. The floor openings are 10 inches by 12 inches in size and are situated at each end of the room, and approximately midway of the width. Two openings in the walls, one at each end below the floor level, allow fresh air to enter the floor openings. All openings are screen-covered to prevent entrance of insects, mice, or other small animals.

The air is kept in circulation by a 16-inch oscillating-type electric fan placed near one of the floor openings. The room is lighted by two 150-watt, daylight-type, electric-light bulbs projecting horizontally from the side walls about 6 feet above the floor and situated midway of the length of the room. Wall sockets are placed in relative positions in the ends of the room for convenient electrical connections.

The winter season in southern Arizona, is mild, yet it is necessary to supply artificial heat in order to keep conditions in a room suitable for the continuous breeding and rearing of *Anastatus semiflavidus*. During last season's studies it was desirable to keep the room at various constant temperatures ranging from 70° to 80°F. This was successfully accomplished by means of a thermal system substantially the same as is described by Baker and Arbuthnot (2). The same writers described a humidifier, and one of the same type is used at the Tempe Laboratory.

As the summer temperatures at Tempe regularly reach a maximum of 100°F., or above, it was necessary to install an effective cooling system if suitable temperatures for parasite rearing were to be obtained. To quite an extent, the selection and installation of the cooling system was of a pioneering nature; unusual climatic conditions, construction of room, and cost of contemplated systems were all factors which made the problem more complex. Specifications were finally completed, and the cooling system was purchased, installed, and put in operation in June, 1930. The system used is of the automatic electric type, consisting essentially of a 1-horsepower, 60-cycle, 110 to 220 volt motor; a two-cylinder, vertical, reciprocating, single-acting-type compressor capable of displacing 10,000 cubic inches at a speed of not more than 500 revolutions per minute; a water condenser; and two copper expansion coils, each with five fins, and measuring 3 feet 5¾ inches long by 15¾ inches wide by 19¾ inches high. The motor, compressor, and water condenser are mounted on the same cast-iron base which rests on the floor of a screened insectary room adjoining the constant-temperature room and within 10 inches of the outer wall of the latter. The expansion coils are situated in the west end of the room in tandem, approximately 20 inches from the west wall, and with a clearance of about 11 inches from the side walls at either end of the extended coil battery. The coils are suspended from the ceiling by means of iron braces and bolts. A drip pan immediately under the coils is 7 feet 3 inches long by 19 inches wide by 1 inch deep and is slightly lowered at one end to allow ready drainage. It clears the floor at approximately an average of 4 feet 9 inches and a hole cut in the lower end is connected by pipe with the

sewer. Two holes cut through the wall of the temperature-control room permit pipe connections between the expansion coils and the compressing machinery outside. Water connections to supply water for the condenser are made outside the control room near the compressing machinery. Sulphur dioxide is the refrigerating medium.

The original specifications demanded refrigeration equipment that would maintain a minimum temperature of 60°F, and a maximum temperature of 70°F., when the outside temperature is 100°F or above, with the machinery running no more than 14 hours out of 24. At no time during the summers of 1930 and 1931 has more than one of the expansion coils been in operation at the same time, and suitable temperatures for the purposes desired, 70° to 80°F., have been maintained. It appears likely that a materially smaller system would have fulfilled the need.

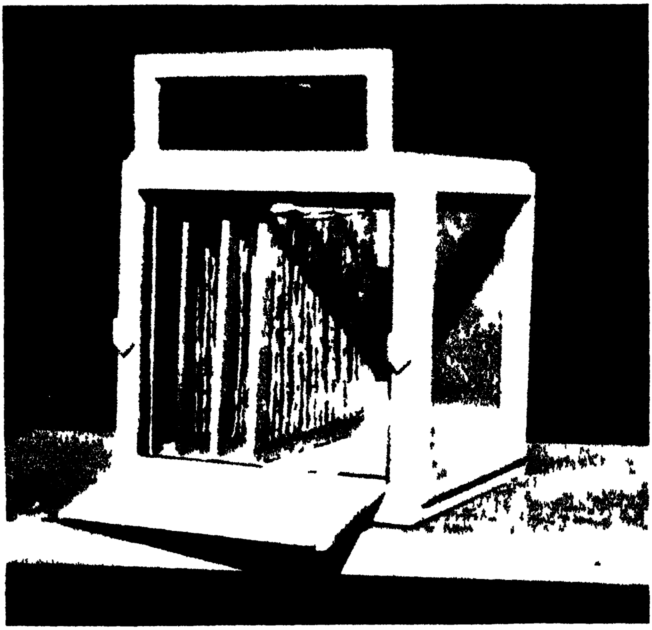
Large numbers of range caterpillar eggs must be kept in a practically dormant state for several weeks or even months both before and after parasitization by *A. semiflavidus*. This is accomplished by two automatically controlled electric refrigerators of the type used for household purposes, each having an approximate storage space of 4 cubic feet. No difficulty has been encountered in maintaining practically constant temperatures with these machines set to run at 35° or 40°F., the temperatures desired in the work to date.

Two automatically controlled electric incubators are used to incubate the parasitized range caterpillar eggs. Inside dimensions are as follows: Larger incubator, 15 inches high by 15½ inches wide by 14 inches deep; smaller incubator, 12 inches high by 10 inches wide by 12 inches deep. The incubators are constructed of asbestos transite with polished copper external trimmings. These incubators have a temperature range from room temperature to 158°F. For use in the range caterpillar work they have been satisfactory when run at desired temperatures of 80° to 95°F. Both incubators are equipped with removable shelves.

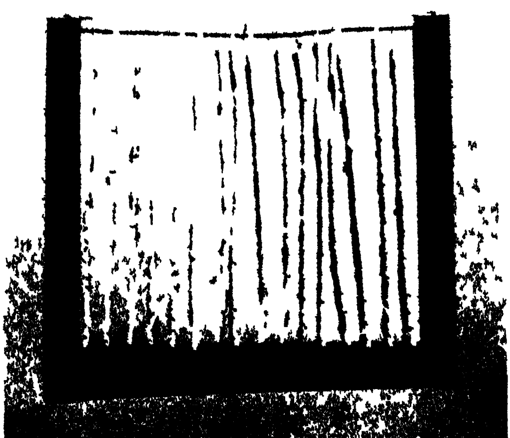
A refrigerator, the humidifier, and the apparatus for heating the temperature-control room are located near the east wall of the room. A shelf, 26 inches wide by 10 feet long and 2 feet 6 inches above the floor, extends along the north wall beginning at the west end of the room. This shelf is used for oviposition cages. A work table 25 inches by 8 feet extends along the south wall. The door is located on the south side of the room about 1 foot from the southeast corner. A considerable amount of storage space is available under the tables and shelves described.

The parasite oviposition cage (Pl. 34, Fig. 1) now in use is constructed as follows: There is a stout wooden framework. The inside dimensions, including space occupied by projecting framework, are 16 inches by 16 inches by 15 inches high. The top, two sides, and the upper door are covered with transparent celluloid. The back is covered with a layer of cheesecloth over which is placed a layer of 16-mesh window screen. The lower door is covered in a similar manner. (The screen permits access of fresh air and the cheesecloth prevents escape of the parasites or entrance of small insects.) The cage is provided with two hinged doors, one directly above the other, so that they meet at the middle of the front of the cage when closed. The upper door opens upward and the lower downward, and each is 6½ inches high and 13½ inches wide. The cage floor is made of beaver board. The exterior woodwork is painted gray and the interior is enameled white. The door facings have strips of felt pasted around them to prevent escape of parasites through small openings around the edges of the doors. Small wooden latches held on by screws and free to turn in either direction keep either one or both doors closed, as desired. A device to hold the egg racks approximately ¾ inch apart and in a vertical position is located in the back of the cage and rests on the cage floor. It consists of a bar of wood ¾ inch by 1¾ inches by 14 inches long placed edgewise so that the ¾ inch dimension rests on the floor of the cage. In the face of the bar toward the front are cut 11 notches ⅜ inch deep by ½ inch wide by 1¾ inches high. A horizontal interval ¾ inch wide separates each two notches. A space of ½ inch is left at each end of the bar. As the material in the egg racks is slightly less than ½ inch in thickness the ends of the racks fit into the notches snugly.

Each cage is made to hold a maximum of 11 egg racks. The racks are 14½ inches long by 12¼ inches high, the two ends and bottom of the frame made of 1-inch by ½-inch wood strips fastened together at the corners with corrugated fasteners. A stout wire nailed at the ends to the projecting wooden ends completes the framework. Along the lower side of the framework ¾ inch from the bottom are driven, at intervals of ¾ inch, 16 ½-inch small-headed tacks, the heads of which are allowed to project about ⅛ inch. Sixteen No. 28 bright iron wires, each approximately 12 inches long, are used to hold the eggs placed on each rack. A small loop is made at one end of each wire, which slips over the head of one of the tacks in the lower bar of the rack frame. After the cylindrical range caterpillar egg masses have been slipped over the wire and it is full, almost to the top of the rack frame, the upper



1 Oviposition cage used in breeding *Instatus semiflavidus*



2 Egg rack

end is bent over the large wire at the upper side of the frame (Pl. 34, Fig. 2).

The New Mexico range caterpillar has one generation a year. The eggs, (*1, p. 65*) are deposited, during September, October, and November, in cylindrical masses around grass or weed stems near the ground (*4, p. 6*), and the species remains in this stage until the following May or early June. As the eggs are firmly glued together and tightly fastened to their support, and as the eggshells are very thick and durable, their handling is much simplified. The eggs are collected by breaking the grass or weed stem a short distance above and below the egg mass. Large numbers of these eggs are collected on the range in northeastern New Mexico from October to March and shipped or brought to the Tempe laboratory.

When the eggs arrive at the laboratory they are immediately placed in refrigeration at 35°F. until they are needed for use in breeding *A. semiflavidus*. As the eggs are needed in the breeding work they are taken from the refrigerator and the grass or weed stems removed; they are then placed on the small wires previously described, which are in turn put on the racks and then placed in the oviposition cage along with other racks of eggs. It is estimated that each wire will support approximately 1,250 eggs. With 16 strands of eggs to the rack and 11 racks to each breeding cage (full capacity) each cage would hold 220,000 eggs. In actual rearing operations only 10 racks, or 200,000 eggs, are placed in the cage at one time, the vacant space being used for food containers and boxes containing parasitized range caterpillar eggs from which *A. semiflavidus* are emerging.

The eggs in the oviposition cages are exposed to *A. semiflavidus* for a period of two weeks, and when highly parasitized are removed from the cages, left in the constant-temperature room three or four days, and then stored in a refrigerator at 40°F. until needed for replenishing stock in oviposition cages or for field liberation in New Mexico. Percentage of parasitism is checked by microscopic examination of the egg punctures on representative egg masses.

A high percentage of parasitism has been secured with a temperature of approximately 75°F. and an average relative humidity of approximately 80 per cent. From our preliminary observations, rather wide fluctuations in the percentage of relative humidity do not appreciably affect parasite activity or oviposition. Good results have been obtained with temperatures as low as 72°F. and as high as 79°F. Under laboratory conditions temperatures above 80°F. are unsuitable for oviposition.

Seven oviposition cages are now available. It is planned to keep six of these cages going all the time during the parasite-rearing period, which usually extends from October to May. This will permit changing the eggs in three cages each week, and allow one extra cage at all times for removing eggs, cleaning, and refilling. Each emptied cage is washed and aired before again being used.

In the field *A. semiflavidus* probably approaches one complete generation each year (*3*). Under controlled conditions it is very probable that six or more effective partial generations can be reared. The parasite has been reared from egg to adult in 21 days at 80°F. When incubation is at 80°F. emergence of the parasites is about at its height at 30 to 40 and gradually declines to 50 or 60 days, then practically ceases.

In the field many fully developed larvae of *A. semiflavidus* remain in the host eggs for two years, and a few for even three years. Under controlled temperature and moisture conditions we have a similar situation, many of the fully developed parasite larvae remaining in the host eggs for several months after emergence has apparently stopped.

Because of irregular emergence and overlapping generations, it has been impossible to work out and follow a definite system in stocking or restocking oviposition cages with parasites. In general, the observation and judgment of the worker, aided by parasitization counts, have determined the number of adult parasites to be used in oviposition cages. The parasitized eggs in small cardboard boxes in lots of 10,000, 20,000, or 30,000 are incubated at 80° to 85°F. until parasites are rapidly emerging. They are then removed from the incubator and placed along one side of the oviposition cage, one or two egg racks usually being left out to make room for these eggs. If emergence is very rapid and a high concentration of females is noticed in a cage, the stock material is removed to a new cage, placed in a cage where the number of parasites is declining, or removed to a cooler temperature to retard emergence. When the emergence rate declines rapidly the eggs are again incubated for a few days and returned to an oviposition cage. When parasite emergence is almost negligible the remaining parasitized eggs are placed in storage at 40°F. to be used later for field liberation. Moistening the eggs occasionally with an atomizer apparently hastens emergence.

A solution of honey water (honey 1 part and water 3 parts) was supplied as food for the parasites. Cotton plugs fastened to corks are soaked with this solution, and are suspended through openings in the ceiling or top of the cage. Each cage is provided with six of these feeding plugs, which are usually supplied with fresh food every three days.

A high degree of success has been obtained with this equipment. Adult female parasites have been kept alive for three months, during which time as high as 355 host eggs have been parasitized by individual females. Provided sufficient host eggs are readily available, it is possible to obtain approximately two million parasitized host eggs per month, during the parasite rearing season (November to March).

To date some six million parasitized host eggs have been returned to the range in northeastern New Mexico, and examination of these liberated host eggs shows that from 85–90 per cent of adult parasites have emerged.

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NEW DEVELOPMENTS IN THE CONTROL OF THE CHERRY CASE BEARER (*COLEOPHORA PRUNIELLA*, CLEM.) IN WISCONSIN

By J. H. Lilly and C. L. Fluke, *Department of Economic Entomology, University of Wisconsin*[1]

Abstract

In past years, control of the cherry case bearer, *Coleophora pruniella* Clem. by dormant oil emulsion sprays has been quite successful on cherries but often failed almost entirely on apples. High percentages of kill on apples were made in 1932. The keynote to successful case bearer control is shown to be thorough spraying from the ground. However, applications thorough enough to give a satisfactory kill often give excessive tree injuries in the Door Peninsular fruit growing area. Dormant lime sulfur was tried in an effort to control this insect without tree injuries, and preliminary trials with it are most encouraging.

The cherry case bearer, *Coleophora pruniella* Clemens, has in recent years become the most important orchard pest in the Door Peninsula fruit-growing area of Wisconsin. Its seriousness is due to a most

[1]This paper is published with the consent of the Director of the Wisconsin Agricultural Experiment Station.

unusual degree of specialization for its own survival. Its body is well protected by a tough case constructed from leaf tissue and it feeds entirely as a semi leaf-mining insect. Its successful control on cherry trees in the past has been followed by the adoption of the apple as host by a majority of the population.

In the past, experimental work on the control of this insect has been largely on cherry trees. Work on cherries in both Wisconsin (2, 4, 5, 9, 12, 13) and Michigan (6, 7, 8) has shown that 6% and 8% strengths of lubricating oil emulsions applied in the dormant stage in the spring gave quite satisfactory control. In Wisconsin, this work was initiated by Granovsky (4, 5) and has been continued by the writers (2. 9) while in Michigan Hutson (6, 7, 8) is responsible for the published work. Although these workers have used three somewhat different methods of checking their results, the kill on cherry has been consistently between 80% and 98% when a dormant oil emulsion spray was properly applied.

When control was attempted on apples (2, 8, 10. 11) it resulted in more or less unsatisfactory kill, even when the same oils were used and similarly applied. This was true in both experimental plots and commercially sprayed orchards. Observations in 1931 indicated that the low kill on apples might be due to any one or more of the following factors: First, cases constructed from apple leaves may be more impermeable to oil sprays than those made of cherry leaf tissue. Second, on apple branches, the cases are often scattered along on the under side of the limb rather than being entirely concentrated about the small crotches as on cherries. Third, the smooth, waxy cherry bark causes the oil to collect in large drops in the small crotches where the hibernating cases are clustered instead of a rather uniform oil film enveloping the entire tree as it appears to do on apples. Fourth, extremely windy conditions prevailed during the time when the 1931 applications were made. The last two factors were probably by far the most important.

In view of these facts, our efforts in 1932 were largely concentrated on controlling the case bearer on apples. Although other materials were tried, most of the work was centered around oil sprays of various types, as they had given control on cherries and are comparatively economical.

METHODS.—Our 1932 oil spray plots were located in one orchard near Sturgeon Bay, and practically all were of the Wealthy variety. The sprays were carefully applied so as to give every limb a complete coverage, and were always sprayed from the ground so as to hit the branches from the lower sides where most of the hibernating cases are

TABLE OF RESULTS WITH OIL SPRAYS ON APPLES—1932

Plot	Materials	Rate	Results 1st count	Results 2nd count	% kill	Remarks
–	Check	—	15,599	8,996	0	42.3% "dead"
1	Kerosene	10%				
	Soap	—	6,824	3,177	19.3	Plots 1 to 4 inclusive sprayed in late fall for a comparison of fall and spring applications.
2	"Diamond Paraffin"	7%				
	"Kayso"	1–100	7,700	1,208	72.8	
3	"Barko"	8%	7,520	240	94.5	
4	"Dendrol"	8%	6,520	258	93.1	
5	"Tiara"	8%				Commercial spraying.
	"Kayso"	1–100	4,816	368	86.8	Medium coverage.
6	"Tiara"	8%				
	"Kayso"	1–100	9,110	73	98.6	Very thorough spraying. Heavy coverage.
7	"Spuria"	8%				Low viscocity oil.
	"Kayso"	1–100	8,797	249	95.1	Good coverage.
8	"Diamond Paraffin"	8%				Good commercial spraying.
	"Kayso"	1–100	8,401	333	93.1	Fair coverage.
9	"Diamond Paraffin"	8%				
	Bordeaux	4–4–50	9,638	689	87.6	Did not give good coverage.
10	"Dendrol"	8%	10,162	155	97.4	Gives excellent coverage.
11	L-1776	8%				
	"Kayso"	1–100	6,593	37	99.0	First of a series of seven oils of varying physical properties as explained below. They were kindly furnished by Mr. C. R. Cleveland of Standard Oil Co. (Ind.).
12	L-1777	8%				
	"Kayso"	1–100	6,797	7	99.8	
13	L-53	8%				
	"Kayso"	1–100	6,365	13	99.6	
14	L-1778	8%				
	"Kayso"	1–100	8,019	133	97.1	
15	L-1779	8%				
	"Kayso"	1–100	8,573	102	97.9	
16	L-93	8%				
	"Kayso"	1–100	7,917	129	97.2	
17	L-1781	8%				
	"Kayso"	1–100	5,094	380	87.1	
18	Kerosene	20%				Perfectly emulsified
	Soap	5–70	5,390	2,546	18.1	Gave good coverage.

located. Even then, partly due to changing weather conditions, some plots were more thoroughly sprayed than others. This will be brought out in the discussion. The "cold-mix" emulsions with "Kayso" were prepared in the spray tank as recommended by Granovsky (3) and the "Dendrol" was prepared according to the manufacturer's directions.

Results of the dormant spray applications were checked in the following manner. An original or total count was made while the tree and its case bearer population were still in the dormant stage, either before or after the spray was applied. Each count limb was selected on a different side of the tree and a substantial paper tag was securely tied to it at a point distal to which somewhere between 50 and 250 hibernating cases were roughly estimated to be present. The cases between the tag and the tip of the branch, including those on the spurs and twigs, were counted and the total number recorded on the tag. Three branches were always counted on each count tree so as to know how many tags to look for when making the second count. When a plot contained less than twenty trees, counts were made on all of them. The smallest plots consisted of 16 trees each.

The second counts were made about a month later when all of the larvae which were capable of doing so had moved to the leaves and started feeding. As it was much easier to count the live insects feeding on the leaves than to search for the dead ones on the branches, the live count was taken and recorded on the tag beneath the total or first count. Adequate counts were made on unsprayed trees. It is important to note that the average per cent "dead" was 42.3% on the unsprayed check trees. This is about the average natural mortality in Wisconsin.

When the figures from the tags were totaled, the per cent alive in each plot was computed. The control was then calculated by the Abbott (1) formula $\frac{X - Y}{X} \times 100 =$ per cent kill, where X = the per cent living in the check and Y = the per cent alive in the treated plot.

Explanation of Table.—The check was a composite taken from unsprayed trees in different parts of the orchard. It seemed desirable for uniformity to use a single figure based on large numbers as the check for all the plot calculations. This eliminated the larger probable error of small counts, as the mortality was fairly general throughout the orchard.

The first four plots were applied on November 11, 1931, as fall dormants. The trees appeared to be entirely dormant at that time, al-

though many leaves were still clinging to them. The day was favorable for spraying. The kill on these plots was not quite as satisfactory as when the same materials were applied in the spring. However, contrary to the results obtained by most other workers, their tree injuries were minimal as compared to the spring applications.

Plots 5 to 10 inclusive were tests made with different commercial proprietary petroleum oils to compare their relative effectiveness and to test various methods of application. The control secured in every plot was, to our best judgment, in an exact ratio to the thoroughness of coverage—the better the coverage the higher the percentage of kill. Plots 5 and 6 of 8% "Tiara" gave 86.8% and 98.6% kill when the only factor varied was the thoroughness of spraying. "Diamond Paraffin" 8% in plots 8 and 9 gave kills of 93.1% and 87.6% when emulsified with "Kayso" and Bordeaux mixture (3) respectively. The emulsifying agent was the only factor varied, but the Bordeaux emulsion did not spread and wet as well as that made with Kayso. These two pairs of plots were in each case applied side by side and on the same day. Both "Dendrol" and "Spuria" are excellent wetting oils. Good coverage and a correspondingly high kill were secured with both of them.

Plots 11 to 17 inclusive were planned so as to test oils varying in unsulfonatable residue, density, and specific gravity. This plan of attack was suggested by the results of Swingle and Snapp (14). Oils L-1776, L-1777 and L-53 gave tests in unsulfonatable residue of 68%, 82% and 96% respectively, while their viscosities ranged only between 80 and 85 by the Saybolt test. Oils L-1776, L-1778, L-1779, and L-93 gave viscosity tests (Saybolt) with ranges within 80 to 85, 100 to 105, 140 to 145, and 180 to 185 respectively, while their unsulfonatable residue was constant at 68%. Oils L-1776 and L-1781 had specific gravities of .8816 and .9071 respectively, while the unsulfonatable residue of each was 68% and their viscosities ranged between 80 and 85 seconds Saybolt. These analyses were all kindly supplied by Mr. C. R. Cleveland. It will be noted that oil number 1776 was the first in each series. As these oils, with the exception of L-1781 with a high specific gravity gave kills ranging from 97.1% to 99.8%, the viscosity and per cent of unsulfonatable residue of the oil used are apparently secondary in importance to the thoroughness of its application in case bearer control. The importance of the specific gravity of an oil is doubtful. It will be noted, however, that plots 1 and 18 with kerosene emulsions failed to even approach a satisfactory control. Tar oil washes, such as "Barko," deserve more trials than we were able to give them this year.

Discussion of Control.—It is now apparent that thorough coverage is the keynote to successful control of the cherry case bearer on apples. This was best demonstrated by the three series of oils of widely varying physical properties, all of which gave a satisfactory kill when thoroughly applied in 8% "Kayso" emulsions. Counts were also made where a grower used 8% "Tiara" in a very light application. He got only a 26.1% kill. Thus 8% "Tiara" gave 26.1%, 86.8%, and 98.6% kills on three different plots, the kill corresponding with the degree of coverage. The two "Diamond Paraffin" plots emulsified with different agents again emphasized the importance of coverage, the better-wetting emulsion giving a correspondingly higher kill. When a drop of the Bordeaux emulsion dried on a twig it always left a greenish residue. Observations showed that where this was abundant over a cluster of cases, all were killed, but where it was lacking many survived. The importance of coverage was still further substantiated by a count made where a grower applied "Barko", a proprietary tar oil wash in a 3.33% strength. He sprayed very thoroughly and got an 89.5% kill. The importance of good coverage is not to be unexpected when we consider that oil is supposed to kill by actual contact.

In spite of their high percentage of kill, petroleum oil sprays do not offer a satisfactory control of the case bearer in Wisconsin because of the hazard of tree injuries. Oil injuries in the past have been of such consequence that some orchardists refused to apply them at all, and most of those who have used them applied them so sparingly that satisfactory controls did not result. These oil injuries have been of three distinct types. First, the development of apple foliage in early spring was markedly delayed and in some cases the leaves on heavily sprayed branches were dwarfed throughout the season. Second, entire spurs or twigs occasionally were "burned" or killed by thorough applications on both apples and cherries. Third, some of the fruit buds were killed, thus lowering the fruit set on apples. This last type has not been checked on cherries. The first two types were readily and commonly noticeable, but the last was probably the most important. Dead blossom spurs were commonly seen when the second counts were made, and a really heavy set has never been observed where petroleum oil was heavily applied. Unfortunately, it is very difficult to definitely evaluate the importance of these injuries. Certainly they are always undesirable, especially on young trees. These injuries were more noticeable in the Door County Peninsula area than most workers have reported from other regions. Two factors are suggested which logically

seem to explain these differences. The soil in this region is quite shallow and the past two years have been more or less dry seasons, marked by a lack of soil moisture. It seems only logical that trees in this area were thus somewhat weaker than normal and subsequently more susceptible to oil injuries. This appears to be especially significant if oils, as is sometimes supposed, injure by blocking off the passage of plant sap to the twigs and leaves. Second, most other work with oil sprays has been done with concentrations lower than 8% and against insects less difficult to control. Evidences of oil injury have been observed with all the oils tried except "Barko" and kerosene.

RESULTS WITH DORMANT LIME SULFUR.—Dormant lime sulfur was tried on the case bearer for the first time this year in an effort to find a satisfactory kill and avoid tree injuries. A dormant application consisting of 10 gallons of Dow liquid lime sulfur to each 90 gallons of water plus arsenate of lead at the rate of four pounds to 100 gallons of spray was the only strength tried. The arsenate of lead was included, not to act as a stomach poison, but in hopes that it might make the lime sulfur more active and possibly make it more adhesive. This spray was thoroughly applied on about two acres of apples and three acres of cherries in a heavily infested area. They were sprayed in the late dormant stage when the buds were considerably swelled. The counts showed an 84.1% kill on apples and 86.5% on cherries. Absolutely no injury could be detected and both plots later appeared to have been even more completely controlled than the counts indicated. This work will have to be duplicated before the results are conclusive.

ACKNOWLEDGMENTS.—The writers wish to express their sincere appreciation of the splendid cooperation rendered them by D. E. Bingham and son and L. P. Nebel, Sturgeon Bay, Wisconsin, orchardists.

GENERAL SUMMARY AND CONCLUSIONS

1. Thorough spraying from the ground will control the cherry case bearer (*Coleophora pruniella*, Clem.) on apples.

2. Dormant oil emulsion sprays have so far shown the best control.

3. Oil emulsions with the best spreading and wetting properties are most effective.

4. Dormant petroleum oil emulsion sprays are undesirable because of the following tree injuries:

a. Killing of some fruit buds, thus lowering the fruit set on apples.

b. Killing of entire spurs when applied in excess on both apples and cherries.

c. Delaying and sometimes dwarfing the development of foliage on apples.

5. Kerosene emulsions up to 20% strength fail to give control.

6. Dormant strength lime sulfur in the late dormant stage gives promise of a practicable control with no tree injury.

7. A tar oil wash has given good control with no evident tree injuries.

8. Dormant oil emulsion sprays applied in the fall gave less tree injury than the spring applications.

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INFLUENCE OF HOST RESISTANCE AND TEMPERATURE DURING DORMANCY UPON SEASONAL HISTORY OF THE WALNUT HUSK FLY, *RHAGOLETIS COMPLETA* CRESS.[1]

By A. M. Boyce, *University of California Citrus Experiment Station*

ABSTRACT

Data obtained during a five-year biological study of the walnut husk fly, *Rhagoletis completa*, show that host resistance (particularly varietal susceptibility) is directly related to hardness of the walnut husk at the time of oviposition activity of the fly. Seasonal adult emergence is dependent upon the action of factors influencing the termination of dormancy, among which accumulated temperature appears to be of prime importance. A comparison of the seasonal history of the insect for the period 1928–1932 is graphically presented.

A five-year biological study of the walnut husk fly, *Rhagoletis completa* Cress., in California, has supplied very interesting information regarding the nature of host resistance and also the effect of accumulated temperature during dormancy upon seasonal emergence of adults. This species is no doubt indigenous to the central region of the United States, around the 100th meridian, where it occurs on wild black walnut (*Juglans* spp.). It was not differentiated from other walnut-inhabiting *Rhagoletis* until 1929, three years after it was known to occur in a small area in this state. It has risen from obscurity to become a major pest of certain of the more important commercial varieties of Persian walnut (*Juglans regia*).

Host Resistance.—Early in the history of this insect in its new habitat, it was recognized that certain varieties of Persian walnut were more susceptible to attack than others. An instance was recorded in 1928, and many similar ones have been recorded since, where over 95 per cent of the walnuts on Eureka trees were infested, while those on the alternately planted Placentia trees were only 2 per cent infested. In general the later-ripening, thick-husked varieties are most susceptible. Since the flies oviposited in the green husk tissue, varietal susceptibility appeared to be due to the physical nature of the husk, i. e., relative hardness at the time of oviposition activity. Accordingly studies were conducted each year from 1929 to 1932 inclusive, to determine the pressure in grams required to puncture the husks of the several varieties of walnuts during the oviposition period of the fly. The entire data

[1]Paper No. 278, University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

comprised a total of over 35,000 punctures. A modified Jolly balance was used to determine husk hardness (Fig. 57). Typical groups of data for a single season, as in 1931, are presented in Figures 58 and 59.

The green husk tissue increases in hardness as the walnut develops, usually reaching a peak during June or early July. After this time the husk softens gradually as the season progresses (Fig. 58). Females are unable to puncture the husk for egg deposition at the peak of hardness; therefore oviposition takes place on the descending slope of the seasonal husk hardness curve. Since the rate of oviposition in 1931 increased rapidly after August 20, reaching the seasonal peak about August 26 (Fig. 60), is appears that oviposition was inhibited until a hardness approximating 1,300 grams per square millimeter (Fig. 58), was reached under the conditions of these tests. (Area of needle-point was 0.2243 sq. mm.)

A brief discussion of Figure 59 is warranted. The Eureka, Franquette, Klondike, and Payne varieties are very susceptible to attack, while the Placentia variety and Seedling are notably resistant or non-susceptible. The husk hardness data given for the Eureka variety from different groves are fairly uniform, with the exception of the data for grove No. 8. This grove adjoins grove No. 1 on the south. It is of especial interest to note that irrigation is not practiced in grove No. 8, while it is an important factor in the orchard practices of most commercially-produced walnuts. The degree of infestation in grove No. 8 was very light, despite the presence of large numbers of colonized flies. In fact observations in this grove over a five-year period have shown that a consistently light infestation exists even when the infestation in the adjoining grove has on several occasions exceeded 90 per cent. The husk of the Franquette variety is shown to be appreciably harder than that of the Eureka at this time. Franquettes mature several weeks later than Eurekas and the peak of oviposition is accordingly reached several weeks later. The data given for the Placentia variety were secured from the same grove, though on different dates, as indicated. Normal harvest for the Placentia begins about September 15; therefore only a few larvae mature from the relatively small number of eggs that are deposited in the husk of this and other non-susceptible varieties.

Accumulated Temperature During Dormancy and Adult Emergence.—Detailed records of adult emergence from the soil during the five-year period (involving over 37,000 flies), show that the seasonal peak varies considerably. A partial summary of these emergence data is presented in Table 1.

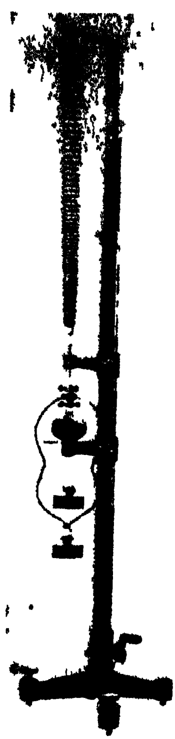

Fig 57 — Jolly balance, modified to determine grams pressure required to puncture green husks of walnuts

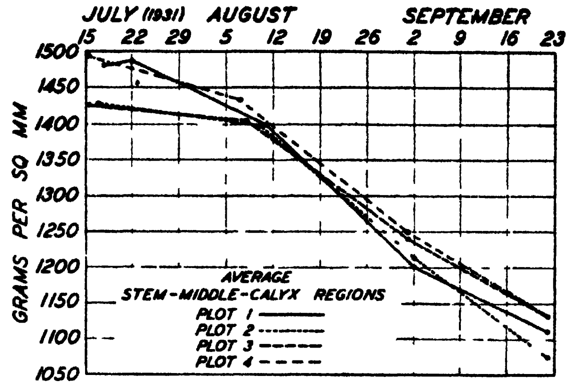

Fig 58—Husk hardness of Eureka walnuts during the period of *Rhagoletis completa* activity (1931) Data obtained from 4 plots in the same grove that were irrigated differently

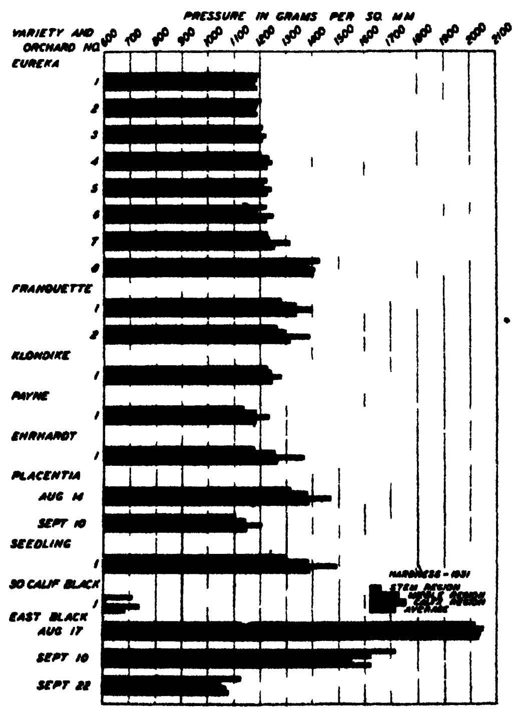

Fig 59—Husk hardness of various varieties of walnuts together with variation in hardness of the same variety in different groves and on different dates. Data collected August 18–22, 1931, unless otherwise indicated

The time of adult emergence is directly dependent upon the action of factors influencing the termination of dormancy, or the diapause. A study of official weather records for the period intervening between the time that 50 per

cent of the larvae entered the soil to pupate and 50 per cent of the adults emerged the following year, reveals interesting relations of temperature to dormancy. These data are summarized in Table 2, and the emergence is graphically shown in Figure 60.

TABLE 1. PARTIAL SUMMARY OF ADULT EMERGENCE DATA (*Rhagoletis completa*)

Year	Date when 50 per cent of flies had emerged	Number of flies ♀	♂	Total	Ratio ♀:♂	Approximate percentage emerged after pupae remained in soil for period of: 1 year	2 years	3 years	4 years
1928	August 17	759	700	1,459	52:48	69.9	28.6	1.21	0.24
1929	August 24	3,956	3,442	7,398	53:47	44.6	55.1—	0.33	—
1930	July 29	4,318	4,647	8,965	48:52	89.9	9.3—	0.85	—
1931	July 18	5,564	6,292	11,856	47:53	83.2	16.8—	—	—
1932	August 16	3,688	3,712	7,400	50:50	66.5	33.5	—	—
Totals and means		18,285	18,793	37,078	49:51	70.8	28.7—	0.79	0.24

The emergence curves (Fig. 60) for the years 1928, 1929, and 1932, if smoothed, may be considered normal frequency polygons, thereby indicating normalcy of emergence. However, the curves for the 1930 and 1931 seasons are materially altered in shape. The abrupt ascent and the multimodal effect probably indicate the operation of abnormal conditions upon the hibernating pupae. Temperature records show that

TABLE 2. SUMMARY OF TEMPERATURE-EMERGENCE DATA REGARDING *Rhagoletis completa*

Year	Total period annual generation individuals remain in soil: Days, Total	Days, Departure from assumed normal	Temperature degrees F: Total day degrees	Daily mean	Monthly departure from normal
1928	321	0	19,232	59.9	+ 1.7
1929	328	+ 7	19,286	58.8	—13.8
1930	306	—15	18,313	59.8	+ 3.6
1931	291	—30	17,486	60.1	+17.4
1932	324	+ 3	18,877	59.7	— 9.0

abnormally high temperatures prevailed during the dormant period for these two years.

At the end of the 1931 season, after four years of study, it became a matter of conjecture as to whether the early emergence in 1930 and 1931 was wholly due to abnormally higher seasonal temperatures, or whether the insect was becoming synchronized with the milder climate of this state. The winter climate of the region in which it is indigenous is quite rigorous, and adults apparently emerge somewhat later in the year than has been recorded for the latest season (1929) in this subtropical region. The matter was economically important here; for, should the flies emerge during mid-June, it is probable that the green husk of all

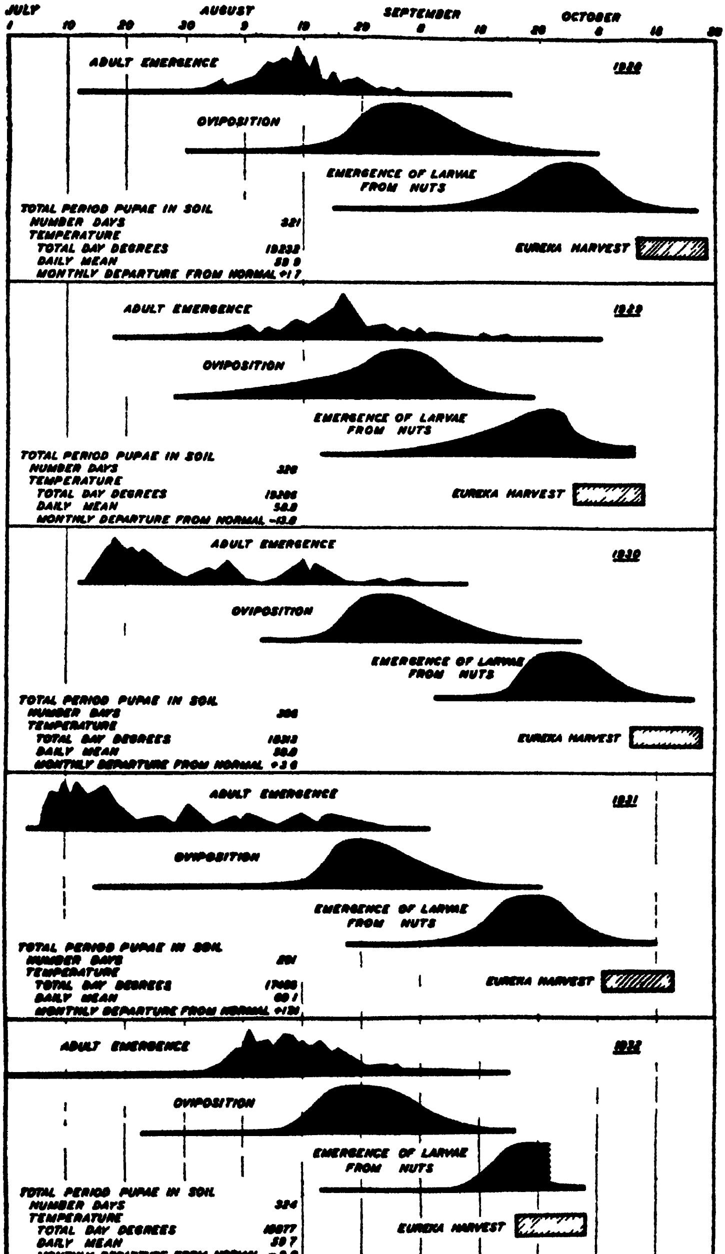

Fig 60—Seasonal history of *Rhagoletis completa* Cress in the Chino-Pomona area, California (1928–1932)

varieties would not have hardened sufficiently to prevent females from ovipositing. In 1932, with subnormally low temperatures and with 355 fewer day degrees temperature than in 1928, 3 more days were required to reach the peak of emergence. This may indicate that the insect is actually becoming acclimatized; however, the differences shown may be within the range of the errors involved.

In consideration of the available information, it appears that an unknown combination of temperatures during dormancy is the most important physical factor governing the time of emergence and also, to a certain extent, the percentage of individuals that constitute the annual generation.

The 1928 and 1929 data particularly (and possibly the data for 1932) indicate that, under the fluctuating temperature conditions prevailing during the period of dormancy, transformation to adulthood was initiated when a certain amount of day degrees temperature was accumulated. This suggests that transformation to adulthood represents the completion of physiological processes that for the most part are dependent upon a combination of temperature conditions peculiar to insects with this type of diapause. Continuing this line of reasoning further, the 1930 and 1931 data possibly indicate that these physiological processes were consummated in a shorter period of time and with less actual heat units when the temperatures were higher during the warmer phase of the fluctuating temperature cycle.

Seasonal History.—From the foregoing data it is evident that the time of adult emergence is subject to factors which result in wide seasonal variations. On the contrary it appears that the time of year at which oviposition occurs remains fairly constant (Fig. 60). The peak of oviposition over the five-year period was reached beween August 25 and September 5. Moreover, with the exception of the 1929 season, the ascending slope of the oviposition curve was relatively steep; indicating, in 1930 and 1931 particularly, that an operative inhibitory factor lost its effect rather suddenly. Since the preoviposition period is from 10 to 20 days, and adults were present on the trees in great numbers for over 30 days prior to appreciable oviposition in 1930 and 1931, the conclusions seem obvious. Females were vainly attempting to oviposit and were not successful until the husk softened sufficiently to permit insertion of the ovipositor. Increased environmental resistance of this nature no doubt constitutes an important factor in the economy of the species. Moreover, should this feature of host resistance become an established fact after a few years of further observation, it would

greatly reduce the expense incident to control measures. The time for treatment would probably become a calendar date, thereby ignoring the emergence of flies for practical purposes, and one application would probably result in satisfactory control.

Another interesting feature is shown in Fig. 60. When Eureka harvest did not begin before October 10, the greater percentage of larvae had emerged prior to harvest. In 1929 the walnuts ripened early with the result that many contained immature larvae in the husk when harvested. The 1932 harvest was the earliest encountered in these studies. Very few larvae had emerged from the husks and many failed to develop. However, in most instances the larvae had developed sufficiently to cause the shell of the nut to become stained, which damage constitutes the primary type of injury. Therefore the extent of injury and resultant economic loss were not materially mitigated.

CONTROL OF THE WALNUT HUSK FLY, *RHAGOLETIS COMPLETA* CRESS.[1]

By A. M. Boyce, *University of California Citrus Experiment Station*

Abstract

Results of laboratory and field experiments regarding control of the walnut husk fly, *Rhagoletis completa*, show that synthetic cryolite and barium fluosilicate were the most satisfactory of the materials tested, which included certain arsenical, fluorine, nicotine, and copper compounds. A table is presented which summarizes the more important data pertaining to a few typical plot experiments conducted during the period 1928–1932.

The Persian walnut (*Juglans regia*) industry of the United States is centered in the state of California, where approximately 97 per cent of the domestic tonnage is produced. There are over 100,000 acres of walnut trees in bearing at the present time. The recorded insect fauna of the genus *Juglans* numbers over 300 species, of which relatively few occur in this state. Before the advent of the trypetid, *Rhagoletis completa*, the only species considered to be of major importance to the industry were the codling moth, *Carpocapsa pomonella* (Linn.), and the walnut aphid, *Chromaphis juglandicola* (Kalt.).

The walnut husk fly, *Rhagoletis completa*, was introduced into California prior to 1926, probably as larvae or pupae in black walnuts (*Juglans* sp.) from the central region of the United States (about the 100th meridian), where it is undoubtedly indigenous. In 1927 the species

[1]Paper No. 277, University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

assumed major economic importance as a pest of certain commercial varieties of Persian walnut. The area of infestation has increased yearly and in 1932 it comprised approximately 500 square miles and included over 2,000 acres of commercial walnut groves.

In 1928 a study of the biology and economics of this insect was begun. These investigations were continued each succeeding year and have been fairly extensive. The problem was "rounded out" in 1932 and a manuscript covering the entire project was prepared for a technical publication. It is the purpose of this paper to "sum up" the more important information obtained regarding the control of this species. The major portion of the work dealt with a determination of the relative merits of the more promising available toxic materials for destroying the adults under laboratory and field conditions, and also with a determination of the effect of these materials on the walnut trees.

Laboratory Toxicological Investigations and Field Studies of Tree Tolerance.—The following materials and combinations have been employed in toxicity tests in the laboratory and in field studies of tree tolerance: acid lead arsenate, basic lead arsenate, calcium arsenate, magnesium arsenate, manganese arsenate, sodium arsenite, barium fluoride, barium fluosilicate, calcium fluoride, calcium fluosilicate compound, magnesium fluosilicate, potassium fluoaluminate, sodium fluoride, sodium fluosilicate, sodium fluoaluminate (cryolite, synthetic), sodium fluoaluminate (natural), copper sulfate, copper carbonate, nicotine sulfate-bentonite, nicotine sulfate-butanol-mineral oil, nicotine sulfate-diatomaceous earth, nicotine sulfate-sucrose, nicotine tannate, ground tobacco leaves, bentonite, calcium hydroxide, diatomaceous earth, sulfur, and fiber talc. The results obtained from the toxicity studies in 1929,[2] 1930,[3] and 1931,[1] have already been published. The data secured in 1932 are presented in Figure 61.

A total of 279 individual toxicity experiments comprising 8,975 flies were conducted during this 4-year period. A brief summary of the more important results follows.

Of the arsenicals tested, basic lead arsenate was consistently slowest in speed of lethal action, though aside from magnesium arsenate it was

[2]Boyce, A. M. Effectiveness of certain materials in producing mortality of the walnut husk fly, *Rhagoletis completa* Cress. California Dept. Agr. Mo. Bul. Vol. 20, pp. 682–690. 1931.

[3]Boyce, A. M. Mortality of *Rhagoletis completa* Cress. (Diptera: Trypetidae) through ingestion of certain solid materials. Jour. Econ. Ent. Vol. 25, No. 5, pp. 1053–1059. 1932.

the only one of the group that did not cause foliage injury. With respect to magnesium arsenate one season's observations indicated that it is safe to use on walnut foliage; however, its lethal action apparently was not appreciably more rapid than that of basic lead arsenate. Of the fluorines tested sodium fluoaluminate (cryolite, synthetic), barium fluo-

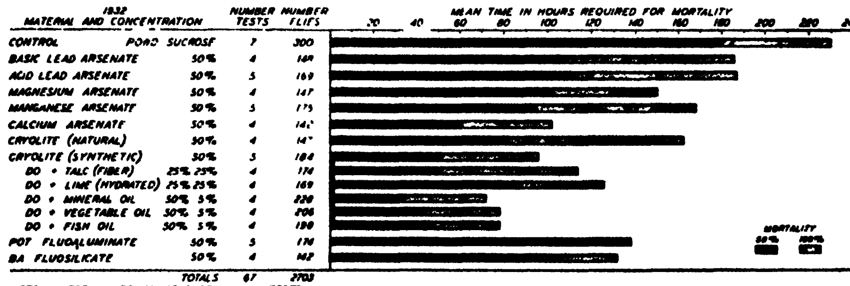

Fig. 61.—Results of toxicity studies in 1932 (*Rhagoletis completa* Cress.)

silicate, and potassium fluoaluminate were the most promising from the point of view of toxicity to the insect and tree tolerance. The copper compounds tested offered promise with respect to lethal action though they were deleterious to walnut foliage. The nicotine compounds and combinations tested were effective as stomach poisons on the flies though they were not as practicable in the field as the several fluorines mentioned. Of the inert diluents, either diatomaceous earth or talc was satisfactory. Hydrated lime employed as a diluent with sodium fluoaluminate materially retarded lethal action. All diluent materials tested, whether chemically active or inert, were lethal to the flies. The incorporation of either mineral oil, vegetable oil, or fish oil, at a concentration of 5 per cent, for adhesive purposes, did not retard lethal action of the insecticide dust mixture. However, at a concentration of 12 per cent both mineral oil and fish oil apparently inhibited the speed of fatality.

Field Control Investigations.—Field-plot control experiments were conducted each season from 1928 to 1932 inclusive. A total of 140 individual plot experiments comprising approximately 300 acres of walnuts were conducted during this 5-year period. A brief summary of the more important data regarding several typical experiments each season is presented in Table 1.

Very erratic results were obtained from the use of basic lead arsenate in 1928 and 1929 as spray and as dust, with nearly full coverage, and also as bait treatments. No doubt variations in host resistance in the nature of hardness of the green walnut husk, and insufficient size and

TABLE 1. SUMMARY OF THE MORE IMPORTANT DATA REGARDING A FEW TYPICAL PLOT EXPERIMENTS IN FIELD CONTROL STUDIES (1928–1932) OF THE WALNUT HUSK FLY, *Rhagoletis completa* CRESS

Year and peak of adult emergence	Material and concentration	Application: Method	Application: Amount per tree	Application: Number	Application: Date	Total number nuts counted	Results: Mean per cent infested	Results: Per cent control
1928 Peak of emergence Aug. 17	Basic lead arsenate 4 lbs.—100 gal.	Spray	20 gal.*	1	8/2	1,334	25.0	64.8
	Check—No treatment	—	—	—	—	1,480	71.0	—
1929 Peak of emergence Aug. 24	Basic lead arsenate 4 lbs.—100 gal.	Spray	20 gal.	3	8/2 8/19 9/3	1,000	11.4	57.8
	Basic lead arsenate 6 lbs., N. O. molasses 5 gal., Cane sugar 25 lbs. — 100 gal.	Spray	5 gal.	"	"	1,139	13.9	48.6
	Check—No treatment	—	—	—	—	934	27.0	—
	Basic lead arsenate 16 lbs., Corn sugar 25 lbs. — 100 gal.	Spray	3 gal.	3	8/3 8/17 9/4	2,307	6.8	74.9
	Basic lead arsenate 100%	Dust	1¾ lbs.	"	"	2,531	3.5	87.1
	Check—No treatment	—	—	—	—	2,114	27.0	—
1930 Peak of emergence July 29	Basic lead arsenate 4 lbs.—100 gal.	Spray	15 gal.	1	7/16	2,141	6.2±1.0	—
	"	"	"	1	8/12	2,160	3.8±0.8	—
	Basic lead arsenate 20 lbs., Hydrated lime 80 lbs.	Dust	3 lbs.	1	7/16	2,152	12.2±3.7	—
	"	"	"	2	7/16 8/13	2,209	6.4±1.4	—
	Barium fluosilicate 20 lbs., Talc 80 lbs.	Dust	2 lbs.	2	7/18 8/13	4,154	0.9±0.2	89.2±0.2
	Basic lead arsenate 20 lbs., Hydrated lime 80 lbs.	Dust	2 lbs.	"	"	449	36.7±6.6	+95.8±1.3††
	Check—No treatment	—	—	—	—	2 621	8.3±1.9	

	Barium fluosilicate 20 lbs.; Talc 80 lbs.	Dust	2 lbs.	1	7/9	4,182	16.9±1.0	45.0±4.5
	"	"	"	2	7/9 8/17	7.299	2.7±0.2	91.2±4.5
1931 Peak of emergence July 18	Barium fluosilicate 3 lbs.—100 gal.*	Spray	15 gal.	1	7/14	9,952	6.2±0.4	79.8±4.5
	" †	"	"	"	"	8,237	17.1±1.1	44.3±4.5
	Check—No treatment	—	—	—	—	6,924	30.7±1.8	—
	Cryolite (Synthetic) 20 lbs.; Talc 80 lbs.	Dust	3 lbs.	1	7/13	2,954	8.5±1.5	62.4±9.7
	Cryolite (Natural) 20 lbs.; Talc 80 lbs.	Dust	3 lbs.	2	7/13 8/17	2,165	3.5±0.5	84.5±6.2
	Check—No treatment	—	—	—	—	2,513	22.6±3.2	—
	Nicotine sulfate (40%) 1 pint; Tannic acid 3 lbs. 100 gal.	Spray	15 gal.	2	7/13 8/5	2,586	13.2±1.8	74.4±5.3
	Barium fluosilicate 3 lbs.—100 gal.	"	"	"	"	2,082	8.2±2.6	84.1±6.1
	Check—No treatment	—	—	—	—	2,693	51.4±8.8	—
	Cryolite (Synthetic) 20 lbs.; Talc (Fiber) 75 lbs.; Mineral oil 5 lbs.	Dust	3 lbs.	2	7/29 8/31	4,167	0.6±0.2	97.3
	"‡	"	"	"	"	6,686	9.2±1.4	57.8
1932 Peak of emergence August 16	Potassium fluoaluminate 20 lbs.; Talc (Fiber) 75 lbs.; Mineral oil 5 lbs.	"	"	"	"	4,627	0.5±0.2	97.9
	Check—No treatment	—	—	—	—	435	21.8	
					7/28	7,800§	22.6±2.2	
	Cryolite (Synthetic) 30 lbs.; Diatomaceous earth 65 lbs.; Mineral oil 5 lbs.	Dust	3 lbs.	2	8/28	7,893‖	7.5±0.9	
						7,782¶	5.9±0.4	
						3,516**	20.9±1.6	
	Check—Untreated isolated susceptible trees in adjoining groves of non-susceptible varieties.	—	—	—	—	1,288	57.2±11.5	—

*Peach interplants treated.
†Peach interplants not treated
‡Border row adjacent to non-susceptible varieties that were not treated.
§West border row. Adjacent west row untreated.
‖Row adjacent to and east of row 1, only 50 feet distant.
¶From major portion of center of grove.
**East border row. Adjacent east row untreated.
††Actual increase in degree of infestation over check.

isolation of plots were contributory factors. Accordingly, during the last 3 years of the study great care was taken to select plots of adequate size, and individual plots were isolated as fully as practicable. Usually four rows of trees that were thoroughly sprayed separated the plots from each other within a grove. Also a bordering zone of non-susceptible varieties was treated. In this manner the general migration of flies from plot to plot was apparently precluded. Furthermore when materials were applied as dusts the "drift" into nearby plots was reduced to a minimum. The data regarding degree of infestation were always taken from the central portions of the plots.

The role of sweet materials in control practices received considerable attention. Chemotropic studies showed that sucrose was not an attrahent for the flies; however when applied to the foliage it served to congregate them during their normal feeding migration about the tree. The period over which both sucrose and New Orleans molasses were palatable to the flies was in direct proportion to the concentration used. At concentrations of 5 and 10 per cent, this period was several days. However, since foliage injury resulted at these concentrations, bait treatments are not particularly promising in the control of this fly.

Barium fluosilicate and synthetic cryolite were more efficacious than basic lead arsenate; consequently they were fairly extensively tested during the latter portion of this study. Their adhesive qualities were low; however, the incorporation of fish oil, vegetable oil, or mineral oil rendered them satisfactory in this respect. Mineral oil was found most desirable for this purpose.

Both fiber talc and diatomaceous earth served as satisfactory diluents for these fluorine compounds when applied as dust. Each material possessed certain qualities superior to the other. Fiber talc was found to be superior to granular talc, and diatomaceous earth from fresh water deposits was superior to that from marine deposits. A specific advantage of diatomaceous earth is that it is very light and bulky and the incorporation of oil for adhesive purposes does not affect its dusting qualities. Furthermore where relatively small amounts (3 to 4 pounds) are applied per tree the operator is more likely to distribute the material thoroughly over all parts of the tree than when applying a heavier material. A bulky material may be disadvantageous in that mixing costs and costs of application are slightly increased; however, the factors already mentioned appear to counteract the disadvantages.

Proper mixing of the ingredient materials is very essential. Series of mixing tests were conducted in a specially designed dust-mixing

plant to determine the minimum time necessary to obtain a satisfactory mixture. These tests showed that 5 minutes continuous agitation of the toxic element (cryolite) with the diluent (earth) was necessary before the oil was atomized into the hopper containing the mixture. Then agitation for 10 minutes longer was required to distribute the oil properly throughout the dust mixture.

Based on the data obtained from field control plots and from general observations on hundreds of acres of commercially treated walnut groves in the infested area, the following conclusions appear to be warranted. Satisfactory control of the walnut husk fly may be obtained through the use of synthetic cryolite (97 + per cent sodium fluoaluminate) or barium fluosilicate. As a spray, the recommended formula is:

Cryolite (synthetic) or barium fluosilicate..............3 pounds
Mineral oil (95 seconds viscosity, 90% unsulfonatable)....1 quart
Water .... 100 gallons

From 30 to 40 gallons per average sized walnut tree affords satisfactory coverage. The economics of the problem favor the dust method of treatment. The recommeded formula is (by weight):

Cryolite (synthetic) or barium fluosilicate............30 per cent
Diatomaceous earth ....65 per cent
Mineral oil (95 seconds viscosity, 90% unsulfonatable)..5 per cent

From 3 to 4 pounds per average sized tree affords satisfactory coverage.

To insure adequate protection within a grove through insecticidal treatment, a zone of adjacent vegetation from 50 to 100 feet wide must be treated simultaneously with the infested grove. In view of the limited duration of experimental work with these materials, two treatments are recommended; the first when adult emergence becomes regular, and the second approximately four weeks following the first.

OBSERVATIONS ON THE HABITS OF FLIES BELONGING TO THE GENUS *RHAGOLETIS*[1]

By M. G. FARLEMAN, *Department of Entomology, Michigan State College*

ABSTRACT

Field observations show that cherry fruit flies appear on the trees earlier than in cages. *R. fausta* is the first species to appear, followed directly by *R. cingulata* and *R. pomonella* three or four weeks later. Influence of light, temperature, moisture, ripeness of fruit, and wild hosts are discussed.

It happens that in the control of both the cherry fruit flies and the apple maggot it is necessary to time accurately the sprays so that they

[1]Journal Article No. 136 (n. s.) from the Mich. Agr. Exp. Sta.

will be applied at a definite period after the first appearance of the adults. At first cages were used, but as time went on it became apparent that we were capturing flies from one to five days earlier by a system of field scouting than through the agency of cages. The use of cages has, therefore, been discontinued and data taken directly from the orchards. The present paper deals with three species: *Rhagoletis cingulata*, on cherry, both sour and sweet; *R. fausta* on cherry, for the most part on sour cherry; and *R. pomonella* on apple. Of these *R. fausta* appears first of all, closely followed by *R. cingulata*. *R. pomonella* appears from three to four weeks later than the cherry fruit flies. The emergence in the case of any one species takes place first in the lower tier of counties and then a wave of emergence gradually progresses northward as the season advances. In 1932 the first emergence of cherry fruit fly took place in Van Buren county on June 7th. The last emergence occurred in Leelanau county on June 14th and at intermediate points the flies appeared in regular order.

Members of this genus pass the winter as pupae in the ground, from which they emerge from June until September. It would be expected that by sweeping the grass of infested areas about emergence-time many specimens resting on the vegetation just above the ground could be taken. Intensive search during three summers in infested locations, however, has yielded but a few specimens from grass sweepings. The flies caught in such places have been taken in both long and short grass, but on some occasions fruit flies seemed to occur in deep grass as a result of their apparent liking for partial shade, although their occurrence after storms may result from their having sought shelter in such places. Sweepings of surface vegetation in cultivated orchards has been uniformly unproductive.

More flies have been caught early in the day and after rain and wind storms than at other times, and though it is probable that occurrence after a rain is correlated with facilitation of movement through the soil, by the softening influence of moisture, the general impression gained from the three seasons' collections is that fruit flies are more readily found when comparatively warm, moist conditions prevail. It is possible also that light conditions in the morning and after storms effect photo-tropic responses which enter somewhat into a determination of the time when fruit flies are observed, for few have been caught except in mingled light and shadow, such as occurs among the leaves on the sunny side of the tree. Further support of this surmise can be drawn from the fact that more fruit flies have been caught on the upper sides

of the leaves on dull days, whereas the opposite condition has obtained on bright days.

Greater numbers of fruit flies have been caught on the middle third of the brighter side than on any other parts of the trees observed. Greater numbers of *R. cingulata* have been caught from the upper half of the tree, while *R. fausta* and *pomonella* are more commonly found on the lower half of the tree. Specimens have never been found resting upon the bark of trees, nor on the smaller twigs. Always they have been found either on the foliage or on the fruit. The greater percentage of the specimens are found on the leaves, but that is natural to expect, since there are greater numbers of leaves than fruit. Where apple and cherry trees are inter-planted, specimens of *R. fausta* have been numerous on cherry and have confined themselves entirely to that plant. Later in the same season this has also been true of *R. pomonella.* Even though the trees were planted closely together, *R. pomonella* has never been collected except on apple, save for one specimen on Montmorency cherry near East Jordan in Charlevoix county late in July of 1931.

As has before been noted, there is an apparent relation between light intensity and the appearance of flies upon the upper or the lower surfaces of leaves. This condition, coupled with alternating dark and light areas upon the wings and with the effect of sunshine through leaves, makes flies of this genus hard to see, despite their characteristic attitude of rest. When disturbed, fruit flies take short, rapid, curved flights, which usually end upon the underside of a leaf. As nearly as can be judged from observation, speed of flight is greatest in *cingulata,* next in *fausta*, and slowest in *pomonella*. Flies of the genus *Rhagoletis* are usually hard to catch, although their capture is somewhat influenced by extremely warm, muggy weather. Under such conditions sixty specimens of *R. fausta* were caught directly into a cyanide bottle from Montmorency cherry trees at one time. Usually, skillful use of an insect net is necessary in the capture of fruit flies. The type of flight and the common habitat among the leaves unite to make sweeping the leaves and branches inadvisable. Another objection to this practice in the early season or where flies are scarce is that the flies readily take flight ahead of the sweeping.

It has been thought that both species of *Rhagoletis* attacking cherry begin ovipositing just as soon as the fruit acquires a little color, after passing through a short period devoted to feeding and mating after emergence. Numbers of *Rhagoletis fausta* were repeatedly observed the first week in June, 1932, trying to oviposit on Montmorency cherries

two or three weeks prior to picking, while the fruits were green and hard. This seems to indicate that before oviposition can be successful, the fruit must be soft enough in texture to allow the insertion of the ovipositor.

Efficient control may be somewhat lessened by infestation from certain wild host-plants that are numerous and particularly adapted to Michigan conditions. *R. fausta* and *cingulata* breed readily in the following: Wild black cherry (*Prunus serotina*), choke cherry (*P. virginiana*), pin cherry (*P. pennsylvanica*), and mahaleb cherry (*P. mahaleb*, escaped from cultivation). *R. pomonella* breeds successfully in hawthorn (*Crataegus*).

A PRACTICAL METHOD OF CONTROLLING *DENDROCTONUS VALENS* LEC.

By Eric Walther, *Golden Gate Park*[1]

Abstract

A method of injecting carbontetrachloride is described and the results given

In common with most other pine-forests of California, the plantations of Golden Gate Park also have suffered from the depredations of bark-beetles, of which *Dendroctonus valens* Lec. must be considered the most dangerous one, by reason of its more primary nature. The relatively high value of individual trees led to an attempt at their treatment, a summary of which is presented here as possibly of wider interest and value.

The idea of killing bark-beetles within their burrows is by no means new; and the utilization of toxic vapors to control boring insects also is well known, as in the case of the peach-tree borer, control of which last with Paradichlorbenzene has become standard practice. As far as the present writer is aware, though, this is the first instance where sufficiently large numbers of pines attacked by *Dendroctonus valens* were actually saved to permit of any sound conclusions as to the practicability of the method and materials used.

Out of a total of about 8,500 Monterey pines around 1,400, or 17%, were attacked by the above beetle during the past 2 seasons, of which number fully 1,200 were successfully treated. These show no injury from the effect of the treatment, and evidence of healing-over of beetle-damaged areas. The number of pines cut as not worth saving amounts to less than the normal annual cut under a rotation of 40 years.

The method finally adopted consists, essentially, of the injection into the beetle-burrows, of Ethylene-dichloride.

[1]Published with permission of John McLaren, Park Superintendent.

Plate 35

A dying pine infested with both mite and beetle

A healthy mountain pine

Plate 36

Injecting burrow

Treated burrow

Tools used

This relatively new product is quite similar in action to carbonbisulphid and carbontetrachloride, but combines the volatility and consequent toxicity of the former with the safety and non-offensive odor of the latter. In practice it was found impossible to inject the liquid through the entrance-holes as found, since the resin very soon effectively clogged up the nozzle of the syringe. It was found advantageous to cut away the outer bark, and the best tool for the purpose turned out to be a cooper's adze, with a rather sharply curved, well-balanced cutting-blade. The outer bark of old Monterey pines is so deeply fissured at the base that it is almost impossible to close all cracks and openings unless this dead bark is trimmed away. Incidentally this serves to mark the trees treated, serving to facilitate rechecking. Injection of the liquid is by means of a common medical syringe holding about one ounce, equipped with a special tip having a broad shoulder and a tip smaller than the beetle-burrow, so that with a little pressure a tight fit against leakage while injecting may be attained. After injection of as much poison as the particular burrow will hold, all openings, cracks, etc., are plugged with putty, so that the resultant vapor is confined as long as possible and given a fair chance to penetrate to all parts of the larval chamber. The area treated is gone over again within 3 weeks or so, when active burrows can readily be spotted by the extruded pitch-tubes or saw dust, and retreated. Efficiency of this method ran very high, often exceeding 95%, dropping below this only on *Pinus pinaster* and badly infested trees. The reduction in results may be explained by the more elongated, narrower burrows of the beetles where they are crowded. Normally the larval chamber of *D. valens* is only slightly longer than broad, permitting the poison-gas to readily reach all larvae, pupae and beetles. It is in any case advisable to commence control-work as early as possible, to avoid serious injury, and to so time the work as to meet the peak of beetle-activity. While no exact statements are possible, locally at least the relative number of active burrows found would seem to indicate the presence here of at least two generations a year, with the spring-brood the larger one. Little activity is noticeable during the cold winter-months, and the peak of activity is reached during May and April, with a second, smaller brood in September.

Of natural enemies the only one noted in numbers sufficient to render it of importance was a predacious mite, apparently of the genus *Parasitus*, nymphs of which were often extremely abundant both on larvae, pupae and adult beetles.

While *Dendroctonus valens* is essentially much more primary than most other bark-beetles, it should be recorded that the pines of the Park, throughout most of its 1,013 acres, were seriously weakened through the lowering of the local watertable consequent upon several dry winters, as well as from the effect of a long-standing infestation of the pine-needle-mite, *Eriophyes pini* Nalepa.[2]

In the course of our operations it was found that here, as elsewhere, the most prolific source of beetles were stumps and felled trees, a complete cleanup of which of course should precede any other work. In a number of cases stumps were found with beetles so nearly mature as to make impossible their removal. These were carefully exposed by digging, and then burned in situ by using fuel-oil fed beneath the stump through a length of pipe from an oil-drum.

The cost of the treatments depends on several factors, as severity of infestation, labor-costs, value of the trees, etc., but in the present case did not exceed $0.25 per tree per treatment. The success of the method outlined depends primarily upon its adaptation to the particular insect concerned, its habits and life-history; and it by no means follows that all bark-beetles may be dealt with in the same manner. Likewise the old recommendations still hold good as to sanitation, reforestation, etc., into which we can not and need not go any further here.

In closing we submit 3 tables which are self-explanatory, and assure all interested that any further information desired shall be gladly furnished on request.

TABLE 1. NUMBER OF ACTIVE BURROWS TREATED DURING EACH MONTH

1931—July	662	11%
August	1302	22%
September	683	11%
October	328	5%
November	241	4%
December	79	1%
1932—January	115	2%
February	100	2%
March	220	4%
April	783	13%
May	797	13%
June	596	10%
(12 months total	5906	100%)
1932—July[1]	476	8%
August	574	9%
September	430	

Active burrows treated during June 1933=104.

Total burrows treated July 1931 to July 1933=18,724.

[1]The first two months of the new fiscal year the reduction in numbers of the beetles amounts to over 46% compared to the year before.

[2]See "Journal of Economic Entomology;" 1925: 830, and 1928: 628.

TABLE 2. EFFECT OF CARBON-TETRA-CHLORIDE ON VARIOUS STAGES OF *Dendroctonus valens* LEC.

A. Nearly mature larvae	Died after	90 minutes
B. Old beetles		150 "
C. Pupae		250 "
D. Young beetles		300 "
E. Checks of all stages		(all alive)

Condition of test—Equal numbers of the various stages were exposed to the fumes only of the gas, 5 ccm. of C.T.C. were placed in a large test-tube corked at the top, inside of which was a smaller tube containing the insects, and communicating with the outer tube by the open top only. For the purpose of this test death was supposed to have occurred when no motion whatever was perceptible after shaking.

TABLE 3. TIME REQUIRED BY VARIOUS CHEMICALS TO PRODUCE APPARANT DEATH

A. Carbon bisulphide	All motion ceased after	15 min.
B. Ethylene dichloride		90 "
C. Carbontetrachloride		300 "
D. Paradichlorbenzene	(All alive)	
E. Checks	(All alive)	

Condition of test—Same as under No. 2; temp. 65 deg. F.; young beetles only used.

DISTRIBUTION OF MAY-BEETLES (*PHYLLOPHAGA*) IN MICHIGAN[1]

By W. F. MOROFSKY, *Department of Entomology, Michigan State College*

ABSTRACT

A study of the distribution of the May-beetles of Michigan in which are discussed the occurrence and range of the sixteen species which are known at present to inhabit Michigan.

The present study was begun in 1927 for the purpose of determining the species and distribution of May-beetles in Michigan. Specimens were collected from forty-one counties, being sent in from different localities by students, county agents, and farmers with inquiries as to their control. As the beetles were received the genitalia were removed, date recorded, and later they were identified. By this means a very good representation of both species and distribution was acquired. Collections were made by the writer throughout the entire period of flight, during 1930, 1931 and 1932. A total of 11,000 adult Phyllophaga were collected and studied. In addition to this the writer has had access to the Michigan State College collection, which dates back to 1874.

Of the forty-one counties from which collections were obtained, eight species were recorded in the northern, fourteen species in the central, and nineteen species in the southern counties.. The writer is led to believe that weather conditions, especially rainfall, play a large part in the distribution of the species.

[1]Journal Article No. 137 (n. s.) from the Mich. Agr. Exp. Sta.

May-beetles of the Three Sections of the State in Order of Abundance

Northern Michigan

Phyllophaga anxia	*Phyllophaga marginalis*
Phyllophaga drakii	*Phyllophaga grandis*

Central Michigan

Phyllophaga rugosa	*Phyllophaga fusca*
Phyllophaga hirticula	*Phyllophaga crenulata*
Phyllophaga anxia	*Phyllophaga tristis*
Phyllophaga futilis	*Phyllophaga drakii*

Southern Michigan

Phyllophaga rugosa	*Phyllophaga ciliata*
Phyllophaga hirticula	*Phyllophaga dubia*
Phyllophaga anxia	*Phyllophaga gracilis*
Phyllophaga fusca	*Phyllophaga gibbosa*
Phyllophaga futilis	*Phyllophaga pruniana*
Phyllophaga crenulata	*Phyllophaga longispina*
Phyllophaga tristis	*Phyllophaga balia*
Phyllophaga ilicis	*Phyllophaga lugubris*
Phyllophaga inversa	*Phyllophaga grandis*

The total number of species recorded in Michigan from 1874 to 1932, inclusive, is twenty-one, of which five are synonyms. The number of specimens collected varied from 7,213 of *P. rugosa* to four of *P. marginalis.* According to the numbers of specimens collected and identified, *P. rugosa* amounted to eighty per cent, with *P. hirticula* and *P. anxia* next. Following are listed seven species which include ninety-five per cent of all specimens collected.

Important Species in Michigan According to Numbers

Phyllophaga rugosa	7,213	*Phyllophaga fusca*	419
Phyllophaga hirticula	963	*Phyllophaga tristis*	298
Phyllophaga anxia	649	*Phyllophaga crenulata*	60
Phyllophaga futilis	468		
Total			10,070

Most of the May-beetles collected were taken at or near electric lights at different times and dates; no special traps were used. This holds true with the exception of species such as *futilis, tristis,* and *crenulata. Futilis* was commonly found under raspberry plants, although it has never been found feeding. *Tristis* and *crenulata* were found early in the spring, commonly under rose. Although no special efforts were made to find host-plants of species, the writer did observe them when possible.

Of the 10,000 May-beetles collected at or near electric lights, approximately eighty-nine per cent were found to be males in all species, except in the case of *P. anxia,* which showed more females than males in all localities collected.

In the following summaries of Michigan May-beetles, an attempt will be made to discuss the seven most important species of the state as to numbers collected, dates, and where found.

Phyllophaga rugosa (Melsh.) was found to be the most abundant

species in the state. Of the 11,000 beetles collected, 7,213 specimens were *rugosa*. The range of this species was found to occupy the southeastern third of the state, extending from Berrien County across to Bay County, including the entire Thumb District of Michigan. The first beetles were collected on May 20th and the last on July 7th. All of the beetles collected were taken at electric lights and, therefore, not checked as to food plants, but there is no doubt but that *rugosa* is one of our most destructive species, especially in the larval stages. According to Forbes in his "Illinois May-Beetles", the adult *rugosa* confines itself mostly to poplars and elms.

Phyllophaga hirticula (Knoch.) was first described by Knoch in 1801 and is found to be more or less common throughout the southeastern United States. It ranks second in abundance in Michigan. Of the 963 specimens taken, forty per cent were collected at electric lights. The sixty per cent collected by the writer were found to be feeding on oak, hickory, elm, ash and black cherry, of which oak was first choice.

Hirticula did not range as far north as *rugosa*. It was found in fourteen counties of southwestern Michigan, as compared with *rugosa,* which was found in twenty-three southeastern counties. The most northern county for *hirticula* was Kent County. It has attracted more attention than other species, as several wood-lots in southwestern Michigan have been completely defoliated by the adults. There would appear to be an overlapping of broods causing a complete defoliation for the past two years, 1930 and 1931. With the aid of *anxia* in 1932, several wood-lots, which had previously been defoliated by *hirticula,* were again defoliated, causing the death of several stands of oaks. The first beetles of *hirticula* appeared on May 20th and the last on July 1st.

Phyllophaga anxia (Lec.) is the most wide-spread of all our Michigan May-beetles and also is our most northern species. It was formerly known as *dubia* and ranges over the entire state, being reported from twenty counties in the lower and from two counties in the upper peninsula, Chippewa and Gogebic, but not in great numbers. Five-hundred and fifty-nine specimens were taken at or near electric lights, while ninety were collected by the writer at night, feeding on oak. This species does not seem to be of economic importance in the lower peninsula. It was collected from May 1st to June 28th. Of the 559 specimens taken at electric lights, approximately seveny-five per cent were found to be females.

Phyllophaga futilis (Lec.) is more or less restricted to the lower southeastern counties in Michigan, and is not of great economic importance. It is found in six counties, Monroe, Lewanee, Washtenaw, Wayne, Liv-

ingston, and Ingham. Three hundred specimens were taken at electric lights from May 20th to June 25th, and 168 adults were collected by the writer during the daytime under raspberry plants in Monroe and Ingham counties, although no injury was found on the raspberry plants.

Phyllophaga fusca (Froel.) is more or less common throughout central Michigan. Four hundred nineteen specimens were taken at electric lights in six counties from April 18th to July 1st.

Phyllophaga tristis (Fab.) is of little importance throughout the south and central portion of the state. It was taken in eight counties. Two-hundred and two specimens were collected near electric lights and ninety-six were collected by the writer just at dusk coming from under rose bushes which were completely surrounded by sod. *Tristis* was always found to be local and its distribution never widespread. Collected from May 5th to June 25th.

Phyllophaga crenulata (Froelich) is represented by sixty specimens taken in four counties centrally located from May 9th to June 23rd.

The foregoing accounts for Michigan's first seven species of May-beetles in order of abundance. Following are listed the sixteen species of May-beetles with synonymy[2] indicated:

rugosa	*drakii = grandis*
anxia = dubia	*forsteri = lugubris*
crenulata	*marginalis*
tristis	*inversa*
hirticula	*gracilis*
fusca	*pruniana*
ilicis = ciliata	*longispina*
futilis = gibbosa	*balia*

This list includes all of the Michigan May-beetles up to this date. The numbers vary greatly in abundance from 7,213 *rugosa* to four *marginalis,* ninety-five per cent of which belong to the seven main species. The rest are distributed among the remaining nine species. It is found that four species of May-beetles inhabit northern Michigan. Eight are restricted to the central, and eighteen are found in the southern portion.

The writer wishes at this time to acknowledge the aid received from A. F. Satterthwait in checking determinations, from E. I. McDaniel in preparation of specimens, from Ray Hutson for criticism of the manuscript, from students who aided in collecting material, and from Dr. R. H. Pettit, Head of the Section of Entomology, for facilities in making the study possible, in addition to suggestion, encouragement and criticism of the manuscript.

[2]The nomenclature of this list is that of Dr. Robert D. Glasgow, as given in Article V, Vol. XI, of the Bulletin of the Illinois State Laboratory of Natural History.

SPRAYING TO CONTROL THE GLADIOLUS THRIPS, *TAENIOTHRIPS GLADIOLI* M. & S., IN MICHIGAN FOR THE SEASON OF 1932[1]

By E. I. McDaniel, *Department of Entomology, Michigan State College*

ABSTRACT

Contact sprays including lead arsenate and glue are found to be more effective in controlling the gladiolus thrips than those without. The liberal use of water during dry weather and the use of fertilizer containing powdered naphthalene give favorable indications.

The distribution of the gladiolus thrips, *Taeniothrips gladioli*, M. & S., for 1932 in Michigan was confined largely to the southern half of the state and the infestations were local rather than general.

The loss was most apparent among commercial growers who had acquired new assortments of corms from several sources or where the corms had been stored over winter at high temperatures. A number of experiments were conducted with combinations of the various contact insecticides with and without lead arsenate to determine which would give the most effective control. Unfortunately, the fields were far apart and in each instance it was necessary to rely on the owner to furnish his own spray rig and to apply the spray. While these factors detract from the value of the experiment, certain interesting facts were established. The following four formulae were tested out on a commercial scale. All sprays were applied about four p. m., since at this time more thrips seemed to be feeding in the open than at any time of day.

RESULTS, SPRAYING FOR GLADIOLUS THRIPS 1932

Treatment	No. of sprays	Results
No. 1. Nicotine sulphate 40%–1.6 fluid ounces Soap............ 8 ounces Water...........10 gallons	16 at 48-hour intervals	Foliage good. Saved about 60 per cent of flowers.
No. 2. *Nicotine sulphate 40%–1 pint Liquid lime sulphur—1 gallon Water...........100 gallons	4 at 48-hour intervals	Seemed to kill all thrips hit, but at end of 48 hours thrips were back in great numbers.

*A large commercial field was used and the spray was made up in 50- to 100-gallon batches and allowed to stand several hours before applying. The same formula used immediately on college grounds give better results.

Treatment	No. of sprays	Results
No. 3. Evergreen (normal strength), 1 pint Lead arsenate.... 1 pound Glue............ 5 pounds Water...........50 gallons	8 at 48-hour intervals	Control good. Both flowers and foliage free from thrips.

[1]Journal Article No. 131 (n. s.) from the Mich. Agr. Exp. Sta.

No. 4.	Lead arsenate....3½ ounces Derrisol.........4 ounces Glue............ 1 pound Water...........10 gallons	8 at 48-hour intervals	Clean foliage and flowers good enough to exhibit at show.

Of the above sprays those containing lead arsenate and glue gave as high as 95 per cent clean plants, and when these combinations were used in flower gardens where it was possible to irrigate and to fertilize the loss from thrips was negligible.

Nicotine sprays frequently failed in the hands of the grower, because too great a dilution was used or the spray was mixed and allowed to stand for several hours before it was applied. The Derrisol-lead arsenate-glue formula in number four gave the best commercial results during 1932. The liberal use of water and a fertilizer containing naphthalene was also found to be helpful.

A CONTRIBUTION TO THE KNOWLEDGE OF THE WESTERN FLOWER THRIPS, *FRANKLINIELLA CALIFORNICA* (MOULTON)

By Stanley F. Bailey, *University of California*

Abstract

A brief discussion of the distribution, importance, and life history and habits of one of the most cosmopolitan Western thrips

Only very recently this most cosmopolitan of western thrips, which has been for some time the subject of discussion among systematists, received its appropriate common name from Mr. Dudley Moulton. The Western flower thrips is a member of the sub-order Terebrantia and of the family *Thripidae*. It was first described in 1911 by Moulton as the variety *californicus* of *Frankliniella* (*Euthrips*) *tritici* and Moulton (1929) listed its synonymy and gave it specific ranking. As is the case with many thrips not in the literature among the first ranking economic species, while they are quite commonly observed and casually collected by entomologists, anent their life histories and habits, little is attested. It is the purpose of this paper to record some notes, chiefly of a qualitative nature, concerning *Frankliniella californica* (Moulton) which were gathered during the last three years.

Distribution and Hosts.—The distribution of the western flower thrips according to Moulton (1929 and 1931) is throughout California, Oregon, Washington, British Columbia, Idaho, Montana, Wyoming, Colorado, Utah, Nevada, and also Arizona. Future collections will doubtless expand its record to include Lower California, Mexico, New Mexico, and perhaps Texas.

It would not be the part of discretion to attempt to list fully the hosts of this insect, as it has been collected from practically all wild flowers and fruit blossoms throughout the area of its distribution.

This anthophilous thrips (both adults and larvae) is seldom seen on the exposed surfaces of its hosts and is, according to Shull's artificial classification (1914), an "interstitial species, living in closely concealed situations, as among florets of composite flowers, or in clusters of young leaves." However, on occasion, the adults may be seen in short migratory flights from host to host.

In regard to the distribution of *F. californica* in relation to altitude, it might be said that, in California, the author has collected this species commonly from sea level to about 4000 feet above and it no doubt occurs at much higher levels.

ECONOMIC IMPORTANCE.—Because of the lack of recognition of this thrips as a distinct species among western entomologists, considerable difficulty is realized in attempting to list its economic history separate from *F. tritici* which, in the past, has generally been designated in the western states by the common names of wheat, alfalfa, and flower thrips. The term "flower thrips" in the Western locale, while taxinomically perhaps covering a multitude of errors, is well fixed in the minds of the economic entomologists and growers and serves well to designate an economic pest.

The principal type of damage is the familiar "silver-spotting" on young fruits, particularly peaches, apricots, oranges, and apples. The feeding of both the adults and larvae upon the flower parts and tender unfolding leaf buds of plants, both commercial and ornamental, yearly totals serious losses by resulting in a poor "set" and malformed and stunted fruits. Alfalfa seed producers have often reported considerable loss from this thrips. Hansen (1929) reported "that when green, hard figs are entered by thrips they become inoculated with organisms capable of producing decays and fermentations in the ripening fruit," *F. californica* thus is involved in a new economic role. Of the "flower thrips" Annand (1926) wrote "They are capable of bringing about cross-pollination of some species of flowers under field conditions in spite of their well-known tendency to 'blight' flowers by sucking juices from the ovary and by the destruction of other tender parts of the flower, including the destruction of pollen grains." Although there are no definite figures to present on the losses from this "flower thrips," and, discrediting many reports erroneous and exaggerated, the situation has been well summed up by Essig (1926) who wrote "Although some thrips may

occasion greater losses to one or more crops, this species (the wheat or flower thrips) outdoes all others in the amount of damage in the aggregate to all kinds of crops."

LIFE HISTORY AND HABITS.—*Seasonal History and Ecological Notes.* —In California, the winter is passed chiefly in the adult stage although a few fully grown larvae are occasionally found during the colder months in flower and leaf buds. There is a preponderance of females in the winter and early spring since the males are apparently shorter lived and less resistant to winter conditions. With the advent of spring, the abundance of this thrips increases rapidly and almost any flower cluster shaken into the hand will give up several adults and larvae. Normally, the peak of the infestation on the native hosts occurs in the late spring. Later, with the drying up of the majority of the hosts, the increasing toughness of remaining plants, and the increased temperature, the population drops sharply and, while there is a production of over-lapping generations throughout the summer, no fluctuations are exhibited. However, again in the fall, with the cooler weather and new plant growth the resultant of the first rains, a gradual increase can be noted in abundance.

Some few experiments of a qualitative nature with a climatic cabinet have indicated the following effects: (1) heat rigor set in at about 114°F. (with adults) as compared with 122.5°F. with bean thrips, *Hercothrips fasciatus* (Pergande), (2) adult activity seemed to exhibit an optimum around 80°F. and has a range below that of *H. fasciatus*, and (3) more feeding was done at high humidities (80% and above) by *F. californica* than by *H. fasciatus*. Experiments with low temperatures have shown that (1) mature larvae can survive as long as 5 days at a constant temperature of 32°F., (2) at the end of exposures of 7 days at 32°F. and 5 days at 30°F., about 50 per cent of the adults survived, and (3) the males cannot resist low temperatures as well as the females. Such observations under controlled conditions extend support to the plausible explanation given above of the seasonal variation in abundance.

The adults have quite commonly lived 20 days in the laboratory and a few individuals lived 39 and 44 days. Under field conditions, the adults normally live three or more weeks and, needless to say, during the winter season, they live three or four months. The males, at all times of the year, appear to be much shorter lived than the females.

Dependent chiefly on the temperature, the egg stage extends over a period of from five days (at 80°F. constant temperature) to about fifteen days or more (outdoors) in the early spring. The larval stage con-

sumes from 9 to 12 days under favorable field conditions and, those larvae found during December, January, and February, doubtless require as long as two months to mature. The prepupal stage requires from 1 to 3 days and the pupal stage from 3 days (at 90°F. constant temperature) to 10 days.

Parthenogenesis.—Investigations on this phase of biology almost yearly add new species of thrips to the list of parthenogenetic insects. All unmated females of *F. californica* tested in the laboratory for asexuality gave positive results. The females were isolated previous to emergence from the pupal stage and oviposition was secured on bean leaves. The progeny, which appeared normal in every case, were not reared to sexual maturity.

Copulation.—Mating is very promiscuous and continues intermittently throughout the life of both sexes. An interesting fact was noted in that the Western flower thrips will mate almost immediately after emerging and before feeding oftentimes while the newly emerged bean thrips will not copulate without first having fed.

Migration.—In general, definite migrations in this order, with the possible exception of the pear thrips, are not recognized. The forced shifting of hosts which takes place on the part of *F. californica* and many other thrips in the early summer (in California) is a gradual migration or "infiltration" caused by the drying up of the wild hosts. It is at this time that crops are exposed to infestations. Then again, in the late summer and early fall, as the crops mature and the foliage toughens, thus hampering both feeding and oviposition, the adults in many cases gradually transfer their activities back to native hosts. A forced migration is occasioned by *F. californica* when the cover crops are plowed under and also when alfalfa fields are mowed. At such times adjacent crops and ornamentals often become very badly infested. Normally, during the middle of the day, the adults are not seen upon the exposed portions of the host, but, in the early morning and late afternoon, they very frequently are seen running about among the buds and flowers and even making short flights from flower to flower.

Abundance on Hosts.—Of the long lists of hosts, some plants seem to offer more favorable conditions to *F. californica* than others for, while found in almost every flower, its abundance varies notably. The reasons for this variable condition are probably several, the chief of which is the morphology of the flower itself, the characteristics of which may or may not offer good protection, be of sufficient succulence to allow feeding and oviposition, and have a blooming period of suffi-

cient length to sustain larval development. Large numbers of this thrips are found particularly on alfalfa, *Ceanothus* spp., and *Brassica* spp.

Other Activities.—Such activities as hatching, feeding, pupation, and oviposition occur in a normal manner representative of the order. Nevertheless, it might be well to state that the eggs are deposited in the tenderest portions of plant tissues and, under magnification, may be seen as minute swellings. Upon hatching, the minute, translucent white larva begins feeding with the typical "rooting" motion of the mouth cone. Only one larval molt on the host has been observed. The larvae, together with the adults, feed gregariously. The larva, when mature, drops from the host to the ground and there seeks a suitable place to transform. Pupae may be found from the surface among debris to 3 or 4 inches below in crevices, under clods, etc., depending on the type of soil. The mature larva does not form a cell or spin a cocoon, it remains quietly resting in its chosen place and there molts, passing through a short prepupal stage, and after again molting, obtains the pupal stage. With another and last molt, the adult emerges from the pupa and crawls to the surface and thence on to the host by short hops and flights.

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THE RELATIONSHIP OF APHIDS TO THE TRANSMISSION OF YELLOW DWARF OF ONIONS[1]

By C. J. Drake, H. D. Tate and H. M. Harris

Abstract

Yellow dwarf, an insect-borne virus disease of the cultivated onion, is discussed. Acquisition and dissemination from diseased to healthy onions are inseparably linked with insect vectors. Over 50 different species of aphids have served as carriers in the experimental tests. So far as known the virus passes winter only in dormant bulbs (diseased bulbs in field and storehouse), which serve as source of inoculum at beginning of each season. Control may be accomplished by complete destruction of bulbs left in the field coupled with planting of disease-free sets and mother bulbs grown in non-infested areas, thus breaking the association of vectors and cause of the disease.

Yellow dwarf is an insect-borne virus disease affecting the onion plant. It is of a systemic nature and is closely associated with the growth and development of the onion, which serves as a very propitious host. Some facts relevant to the relationship existing between its causative agent and certain aphids have been discussed in previous papers. Also sufficient experimental evidence has been presented to establish the rôle played by these insects in carrying the inoculum from diseased to healthy onions and to prove that the epiphytotics of the disease are inseparably linked with the fortunes of the vectors. In the furtherance of these studies recent work at Pleasant Valley, Iowa, has added many species to the list of potential carriers and has given valuable data on their occurrence and habits in the onion fields.

The first diagnostic features of yellow dwarf become visible in the young onion sets on the fourth or fifth day after the introduction of the etiologic agent by means of the bites of aphids, and by the twelfth day about 95 per cent of the successfully inoculated plants have exhibited characteristic symptoms. The incidence of the initial appearance of the primary symptoms in 1716 sets, experimentally inoculated through the feeding of aphids, is depicted in the accompanying graph (Fig. 62). When the infective principle is introduced into nearly mature or older leaves, the macroscopic symptoms apparently never appear directly on them. Irrespective of the point of introduction, however, the pathognomonic expressions always show first on the new and rapidly-growing shoots, and all subsequently developing leaves display typical chlorotic areas. Sometimes the disease may be present in a masked or symptom-

[1]Journal Paper of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 135.

less form for a part or even all of the current growth period. As a consequence of age at the time of infection there is a greater frequency of masking among the older and nearly mature onions

Plant lice acquire the causal agent during their first feeding upon diseased onions and immediately thereafter are capable of infecting healthy plants, thereby eliminating the hazards that necessarily would

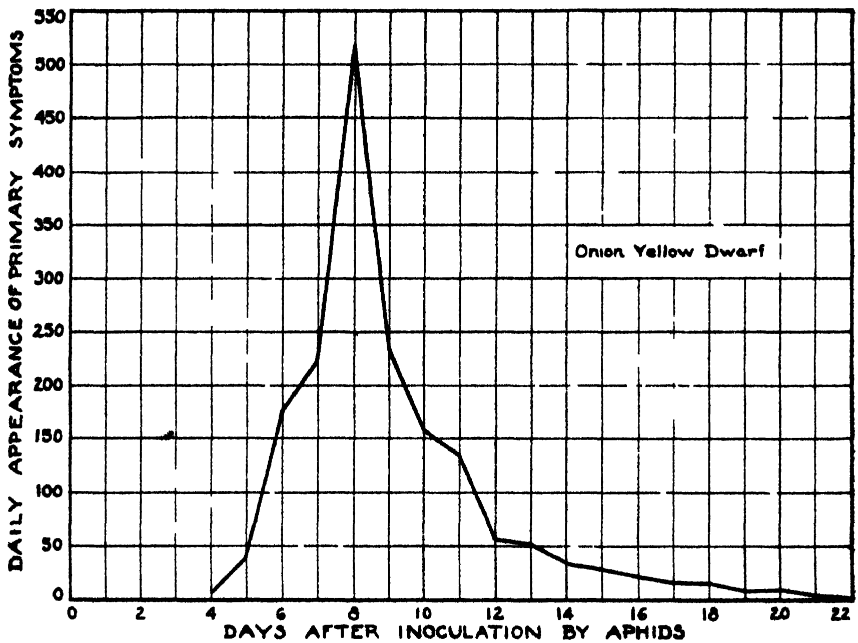

Fig 62—Incubation period and daily appearance of primary symptoms of yellow dwarf in 1716 onion sets inoculated by means of the bites of viruliferous aphids

be encountered should a prolonged incubation period in the insect be obligatory. If there is a latent period in the insect, it is extremely short, and aphids thus seem to have very little, if any, more than accidental connection with yellow dwarf, yet they served as the only important and perhaps sole means of transference of the infective principle under natural conditions. On the third or fourth day after being inoculated by viruliferous plant lice, the growing onion itself becomes a source of infection and harbors the virus throughout life, even though the usual expressions of the disease may be concealed.

Although probably not the autochthonous host, the cultivated onion is a very favorable ambient for the yellow dwarf virus. When transferred from disaesed to healthy plants during the natural process of

feeding of aphids the virus increases in quantity, becomes systemic in its distribution, and usually manifests its presence by the production of definite and characteristic macroscopic symptoms. Moreover, it is capable of living through long periods in the dormant bulb. In the insect, on the other hand, the virus displays not so marked a host-specificity. Here it seems to be incapable of reproducing itself, and in fact soon loses its infectiousness. It has no apparent effect on the insect, and a virus-bearing aphid is not recognizable as such except by a study of the effect of its feeding on the onion. An infected onion thus may serve as an unlimited source of inoculum for the vectors, whereas an aphid, unless having almost constant access to the contagium, can inoculate only a few plants. Therefore, since the disease is not seed-borne and wild hosts are unknown, it is patent that the initial source of inoculum for aphids in the spring is the foliage of bulbs which were infected during the previous season. Under actual field conditions these overwintering "harborers" of the disease include many volunteer bulbs left in the field and waste piles in addition to those infected plants that might have been gathered for transplanting purposes. With aphids as carriers and with diseased bulbs it is possible to infect serially an endless number of plants. *A priori* there is a progressively increasing number of foci of infection for the vectors as the season advances.

Although inoculable, the virus of onion yellow dwarf is not of a highly infectious nature and can not be spread by ordinary contact. Man, insects, and other animals do not serve as passive conveyors of the disease by its adherence to the appendages or clothing, nor can the disease be disseminated mechanically on insect cages and farm equipment. Numerous tests have failed to show that the disease may be transmited by feeding activities of such insects as grasshoppers, beetles, cutworms or other caterpillars, and coleopterous larvae. Tests also have failed to incriminate onion maggots, thrips, bulb mites, and many other primary and secondary pests which ravage the onion plant.

In a recent publication the term "transitory" host was applied to the onion because aphids can not breed, or even live for any appreciable period, when caged upon this plant. The onion seems to serve largely as a place to rest and as a temporary source of nourishment during their fortuitous wandering and migrations. Migratory and summer forms of some species imbibe the juice of the onion very readily whereas others are more or less hesitant about feeding on it. Two species (*Cinara pini* Linn. and *Eulachnus rileyi* Williams) and the stem mothers of certain other species perished in the experimental cages without even at-

tempting to feed upon the onion. Yet some individuals of those aphids living on weeds and cultivated vegetation now and then wander upon the foliage of the onion plant and partake of its sap. Apterous viviparae of some of the more active species, like the pea aphid (*Macrosiphum pisi* Kalt.), were frequently found on onions as far as 100 feet from any other plants. Most aphids, particularly polyxenoid species, feed rather readily on the onion in the absence of customary hosts.

Previous to the establishment of the association existing between aphids and yellow dwarf, very little attention was given to the occurrence of these insects in onion fields. The number of different species as well as the number of individuals of any one species involved in the transmission of the disease depends greatly upon the numbers and kinds of hosts growing in or near onion fields, the numbers of predators and parasites, the weather, and other factors that affect the complexity of the local environment.

During the past summer, May 10, 1932, *M. pisi* (Kalt.) was the first plant louse found at Pleasant Valley feeding on onions; three days later plat counts showed the population of this species to average around 2500 individuals per acre in fields bordering alfalfa. In fact the pea aphid was the only species of any consequence in the onion fields up to the middle of May. By May 20 the bean aphid was as common and generally distributed in the onion fields as the pea aphid. Thereafter, the bean aphid (*Aphis rumicis* L.), the sunflower aphid (*Aphis helianthi* Monell), and the lamb's quarters aphid (*Hyalopterus atriplicis* L.), together with several other species, were also present.

The melon aphid (*Aphis gossypii* Glover) was the commonest species in many onion fields during the latter part of July, both in 1931 and 1932. Records for several seasons show the apple grain aphid (*Rhopalosiphum prunifoliae* Fitch) to have been by far the dominant species after the onion crop was harvested and that it was largely responsible for the spread of the disease among volunteer onions in the fall.

In many onion fields certain species of weeds, such as lamb's quarters, clover, purslane, grasses, and the like, succeeded in establishing themselves, especially during periods of wet weather. Irrespective of size or location of weeds in the field, they soon became populated with plant lice. Not infrequently from 50 to 75 pea aphids were found on sprigs of clover here and there in large onion fields. As many as 300 specimens of the bean aphid have been collected on a single weed; and numerous other species of aphids have also been found in numbers on weeds in onion fields. Eventually, at least in many cases, the weeds

are cut or pulled by the growers, thus forcing both nymphs and adults to migrate in search of food. Under such conditions it is not uncommon to find from a few to 30 or more aphids feeding on a single onion plant near a recently cut weed. As an illustration of the inherent tendency of many species to wander, individual pea aphids have been observed to feed upon four different onion plants within a period of 30 minutes. This restlessness no doubt is due somewhat to the fact that the onion is not a satisfactory host.

In the course of the experiments in the vicinity of Pleasant Valley and at Ames, Iowa, many different species of aphids have been taken on the foliage of onion, weeds in onion fields, and cultivated and wild plants in bordering and nearby areas. As a consequence of their bites the virus of onion yellow dwarf has been transferred from diseased to healthy onions under field and greenhouse conditions by the following species of the family Aphididae: *Amphorophora rossi* Hottes and Frison, *A. rubi* (Kaltenbach), *Anoecia* sp., *Aphis ageratoidis* Oestlund, *A. cardui* Linnaeus, *A. decepta* Hottes and Frison, *A. forbesi* Weed, *A. gossypii* Glover, *A. helianthi* Monell, *A. laburni* Kaltenbach, *A. oenotherae* Oestlund, *A. oestlundi* (Gillette), *A. pomi* DeGeer, *A. rumicis* Linnaeus, *A. viburnicola* Gillette, *Brevicoryne brassicae* (Linnaeus), *Calaphis betulella* Walsh, *Capitophorus flaveolus* (Walker), *C. ribis* (Linnaeus), *Chaitophorus quercicola* (Monell), *C. viminalis* Monell, *Clavigerus salicis* (Linnaeus), *Drepanaphis acerifoliae* (Thomas), *Hyalopterus atriplicis* (Linnaeus), *H. pruni* (Geoffrey), *Hysteroneura setariae* (Thomas), *Macrosiphum ambrosiae* (Thomas), *M. gei* (Koch), *M. gravicornis* Patch, *M. impatienticolens* Patch, *M. pisi* (Kaltenbach), *M. purpurascens* (Oestlund), *M. rosae* (Linnaeus), *M. rudbeckiae* (Fitch), *M. taraxaci* (Kaltenbach), *Microsiphum artemesiae* (Gillette), *Monellia caryella* (Fitch), *M. caryae* (Monell), *Myzocallis alhambra* Davidson, *M. asclepiadis* (Monell), *M. ononidis* (Kaltenbach), *Myzus cerasi* (Fabricius), *M. monardae* (Williams), *M. persicae* (Sulzer), *M. porosus* Sanderson, *Periphyllus negundinis* (Thomas), *P. populicola* (Thomas), *Prociphilus corrugatans* (Sirrine), *P. fraxinifolii* (Riley), *Rhopalosiphum prunifoliae* (Fitch), *R. pseudobrassicae* (Davis), *R. rhois* Monell, *Thripsaphis ballii* (Gillette), and several other species not as yet determined. The writers are greatly indebted to Dr. F. C. Hottes for the identification of the aphids.

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OBSERVATIONS ON THE FEEDING HABITS OF THE POTATO PSYLLID (*PARATRIOZA COCKERELLI* SULC.) AND THE PATHOLOGICAL HISTORY OF THE "PSYLLID YELLOWS" WHICH IT PRODUCES

By J. R. EYER, *Entomologist*, and R. F. CRAWFORD, *Plant Pathologist, New Mexico Agricultural Experiment Station*

ABSTRACT

Studies of histological sections of *Paratrioza cockerelli* in feeding position on potato foliage show the setal sheath penetrating the mesophyll into the border parenchyma immediately surrounding the vascular bundles. The majority of feeding seems to occur in this region. Further examinations of diseased leaves and stems reveal abnormally large deposits of chromoplastids, probably starch granules, in the chlorenchyma of the leaf and in the cortex and pith of the stem.

Investigations, carried on during the past three years at the New Mexico Agricultural Experiment Station to determine the more important insect pests and plant diseases limiting the production of Irish potatoes in the state, have revealed that the Potato Psyllid (*Paratrioza cockerelli* Sulc.) and the "Psyllid Yellows" disease which it produces, is one of the most important factors concerned.

Altho the injurious effect of the feeding of this insect has been recognized since about 1915, "Psyllid Yellows" as a distinct disease was first described by Richards (1) in 1927. It is widely spread throughout the Rocky Mountain potato growing regions and is regarded as one of the most serious potato diseases and difficult to combat. The exact nature of the causal factor has not been demonstrated and the insect vector is not easily controlled by insecti-

cides ordinarily employed for sucking insects. The observations and experiments described in the following discussion were conducted to determine whether any relation could be found to exist between the external symptoms of the disease and the plant tissues invaded and altered by the feeding of the Potato Psyllid.

SYMPTOMS.—Psyllid Yellows is sometimes confused with potato leafroll because of the rolling, "cupping" and yellowing of the leaves, and with Rhizoctonia because of the production of aerial tubers. The following distinctive characters, however, have been outlined by Richards (2).

1. The early symptoms consist of an upward rolling of the basal portions of the young leaflets at the tips of the branches, this condition becoming more pronounced as the disease progresses. In most varieties of potatoes a distinct yellowing of the foliage accompanies this symptom or in Bliss Triumph and Cobbler varieties a reddish or purplish discoloration appears in the rolled portions.

2. The nodes, particularly those of the younger portions of the stem, become enlarged causing the stems to stand out from the main stalk at a characteristic angle (Plate 37, Fig. 1).

3. All buds become abnormally active resulting in the production of accessory shoots and aerial tubers. The entire plant assumes a "stalky," "bushy," or "rosetted" appearance. (Plate 37, Figs. 1 and 2).

4. Below ground the proliferation takes the form of numerous small tubers, in "chains" along the older stolons or in clusters at the nodes. The tubers thus formed frequently give rise to sprouts which develop into leafy branches when near the surface or into secondary tubers which further produce new plants.

5. In the later stages of the disease the older leaves become yellow, develop necrotic brown areas, and drop, leaving only the younger adventitious foliage on the primary stems. (Plate 37, Fig. 2).

Observations in New Mexico on Cobbler and Red McClure varieties confirm these symptoms as characteristic.

INOCULATION EXPERIMENTS.—A series of experiments in which Paratrioza nymphs were transferred from diseased to healthy potato plants were carried out and it was observed that the disease could be readily produced in healthy plants in field cages by this method of infection. The producing of the disease in the greenhouse or in laboratory cages was less certain, however, light intensity apparently being an important factor concerned with the producing of characteristic symptoms. Nymphs reared from eggs deposited by adults

on healthy potato plants failed to produce the disease, supporting the conclusions of Binkley (3) that the infective principle is not carried to the next generation through the egg or that the simple mechanics of feeding does not produce the disease.

Histology of the Feeding Punctures.—To further determine whether the mechanical nature of the feeding as revealed by study of the histological features might produce systematic disturbances sufficiently severe to cause the symptoms already described, serial sections were made of nymphs feeding on potato foliage. Technique similar to that employed by Horsfall (4) in investigating the feeding punctures of aphids and by Smith and Poos (5) with leafhoppers was used.

The following observations and comparisons developed as a result of these studies. The Potato Psyllid is primarily a leaf feeder, the majority of feeding in the field being carried on from the lower surface of the leaf. However, a few individuals have been observed feeding on the stems or petioles and some feed from the upper surface as noted by Knowlton and Janes (6). This feeding position may be due to shade rather than preference for any particular part of the plant.

The beak consists of a pair each of greatly attenuate mandibles and maxillae (Plate 38), Fig. 1), and is readily traceable in serial sections. The setal sheath, as described by Horsfall for aphids and by Smith and Poos for leafhoppers of the genus Empoasca, is not as distinct or constant in occurrence as for these other insects. Penetration is not necessarily intracellular nor do the mouth parts always follow the middle lamella. Actual penetration of cells by laceration frequently occurs (Plate 38, Fig. 2), particularly in the region of the spongy mesophyll, or the beak traverses the intercellular spaces until it reaches the border parenchyma surrounding the vascular bundle. A short setal sheath frequently does occur, however, after the beak has reached the border parenchyma and the particular cells injured, (Plate 38, Fig. 3) can be determined. The phloem parenchyma cells which border the xylem in the larger veinlets or the companion cells and modified parenchyma which form the major portion of the vascular bundles in the smaller veinlets are the regions of the leaf where most extensive feeding occurs.

Penetration of the xylem itself occurs only occasionally and no extensive plugging of the xylem of the leaves or stems, as recorded by Smith and Poos for *Empoasca fabae*, was observed. Frequent alter-

ations in the phloem, particularly the border parenchyma, were observed, however, in the form of destruction and collapsing of these cells and the filling of the resulting cavities with granular materials. (Plate 38, Figs. 4 and 5). Parenchyma cells adjoining the injured portions often contained starch granules in noticeable numbers (Plate 39, Fig. 1). Alterations in the size and position of the nuclei and chloroplasts were occasionally observed in connection with such changes.

HISTOLOGY OF THE DISEASED STEMS.—The effect of these feeding operations in the leafy portions of the plant are also noticeable in the stems. Sections of diseased stems and petioles show abnormally large deposits of starch granules in the cortex and pith (Plate 39, Figs. 2 and 3), and this condition increases with the severity of the disease. Granular deposits, disintegration of the phloem or other bundle alteration as described by Artschwager (7, 8) for potato leaf roll and other "phloem necrosis" diseases, were not observed. In connection with the thickening and enlarging of the stems an attendant thickening of the cell walls was noticeable however.

CONCLUSIONS.—This study, although still incomplete allows the following conclusions and generalizations:

1. The nature of the feeding of the Potato Psyllid is not such as would induce Psyllid yellows symptoms by wholesale destruction or mechanical plugging of the vascular tissues.

2. The principal objective, being as it is in the border parenchyma surrounding the vascular system, apparently interferes with translocation at inception. Since a chlorotic condition is one of the symptoms of Psyllid Yellows this inhibition of translocation is very probably complicated by disturbances in the photosynthetic activities of the plant.

3. This region of extensive feeding is so located that primary disturbances could readily be accentuated by the injection of some infectious principle or disturbing enzyme.

Further investigations are in progress, to determine more exactly by microchemical methods, the physio-chemical nature of the effect of the feeding activities herein described.

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EXPLANATION OF PLATES

Plate 37

1—Irish Cobbler Potato affected with Psyllid Yellows (left) compared with healthy plant of same variety, (right); 2—Irish Cobbler Potato Plants affected with Psyllid Yellows. Plant on right shows aerial tubers and "rosette" type of adventitious foliage. Plant on left shows enlarging of stems and loss of all primary foliage.

Plate 38

1—Sagittal section thru anterior part of *Paratrioza cockerelli* in feeding position on potato leaf blade showing structure of "beak" and penetration of epidermis. (× 49). 2—Cross section of potato leaf blade showing setae of *P. cockerelli* penetrating lower epidermis and spongy mesophyll. (× 120). 3—Same showing setae crossing mesophyll and penetrating a small vascular bundle. Setal sheath well developed in distal portion of feeding region. (× 230). 4—Cross section of spongy chlorenchyma region of leaf blade illustrating feeding injury. Two parenchyma cells have collapsed and resulting cavity is filled with granular material. Parenchyma cell at lower right shows an enlarged nucleus. (× 418). 5—Enlarged view of same showing distal portions of setae embedded in collapsed parenchyma cell.

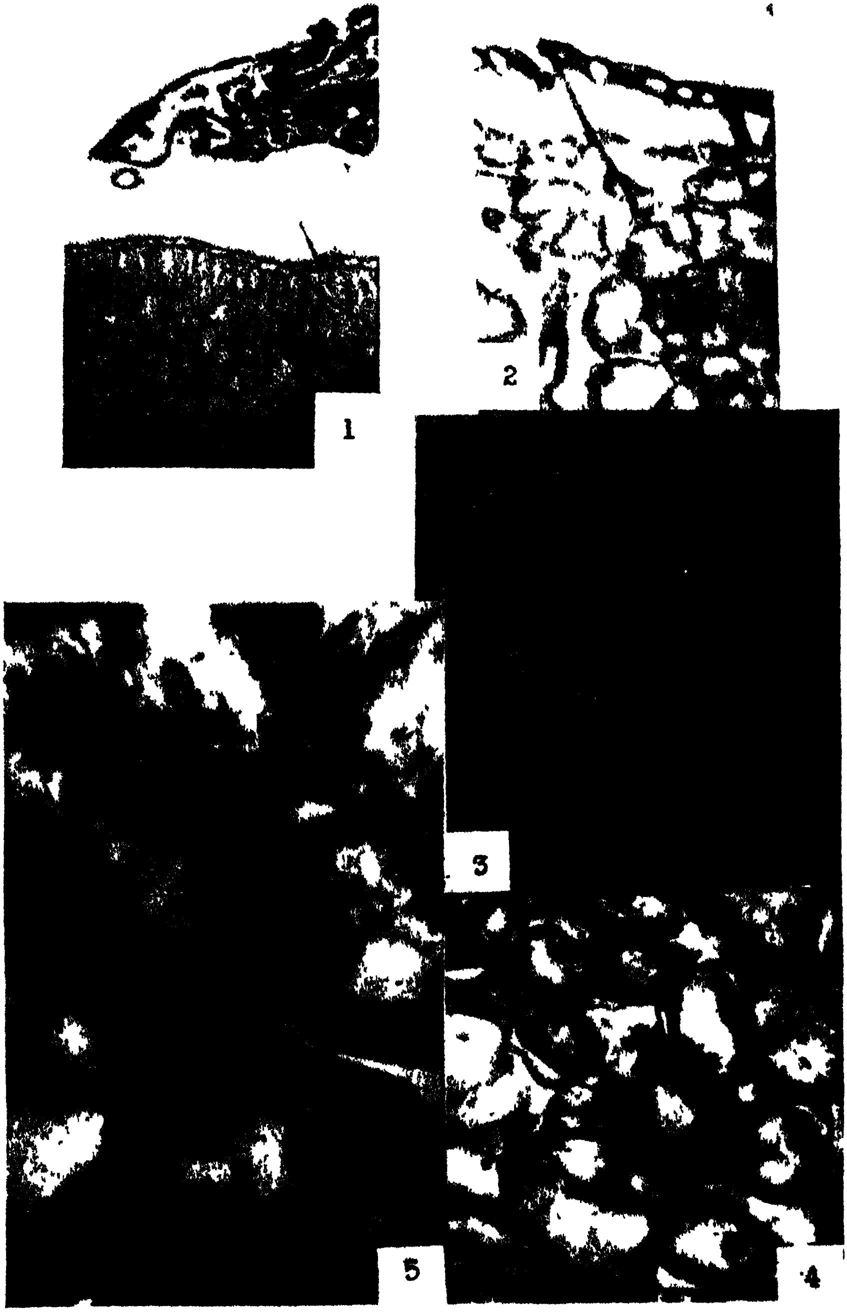
Plate 39

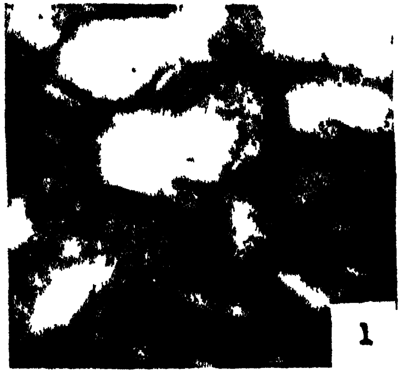
1—Parenchyma cell adjoining injured region illustrated in Plate 38, Fig. 5, filled with starch granules. 2—Cross section of potato stem (internodal region) affected with Psyllid Yellows showing deposits of starch granules in cortex, endodermis and pith. (× 96). 3—Longitudinal section of same. (× 96).

1

2

Plate 38





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VARIATION IN THE POPULATION DENSITY OF THE CALIFORNIA RED SCALE, *AONIDIELLA AURANTII* MASK., IN A HILLY LEMON GROVE

By WALTER EBELING, *University of California Citrus Experiment Station, Riverside, California*

ABSTRACT

Observations made in a hilly lemon grove indicate that the more elevated portions of the grove have the highest average temperature and that the population density of the California red scale in this grove is a function of temperature.

A number of years of rather extensive field experimentation with the California red scale, *Aonidiella aurantii* Mask., in certain hilly sections of southern California, such as the Yorba Linda district, had led the writer to believe that citrus trees in the more elevated districts are usually more heavily infested with red scale than those in the lower districts; and, likewise, in any given grove, the trees in the highest portions of the grove usually have the greatest infestation of scales. It is a common observation that the red scale can be more easily controlled by the usual control measures in the less elevated portions of groves than on the higher elevations. This would indicate that more severe or more frequent control measures could be advantageously employed in the higher areas of the grove.

It has been our observation for a number of years, and has been indicated by Knight (1931), that the mortality of insects from oil sprays is lower on heavily infested fruits than on lightly infested fruits. It is possible that the lower mortality of insects on heavily infested fruits may be due to the roughened surface of the fruit, caused by the encrustation of scales, causing a lighter deposit of oil. The effect of the character of the surface sprayed on the oil-depositing qualities of the spray is discussed by Smith (1932). It would also appear that when trees are so heavily infested with red scale that the insects actually overlap at their margins, the mortality resulting from fumigation would be somewhat lower than when the trees are more lightly infested, due to the protection afforded by the overlapping scale margins.

With these practical considerations in mind, it was deemed advisable to secure more exact data on the influence of elevation upon the population density of the red scale. A lemon grove typical of the more hilly portions of the Yorba Linda section in California was selected for this purpose (Figure 63). Beginning at the northeast

corner of the grove, the number of insects per given unit was counted on every fourth tree throughout the grove. The unit comprised a portion of a branch one inch in diameter and two inches in length. Only the insects seen from one aspect were counted. Twenty units, selected at random throughout the tree, were examined.

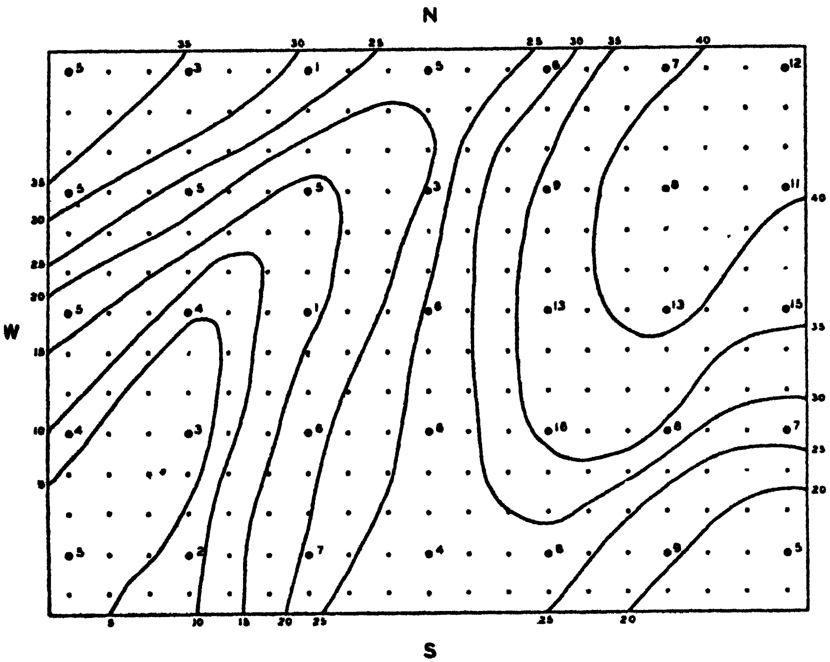

Fig. 63.—Contour map of a hilly lemon grove. The numbers outside the border of the chart indicate relative elevation in feet. The numbers inside the border are a comparative index of the number of red scale occurring on every fourth tree throughout the grove.

The numbers in Figure 63 are the number of insects counted, divided by 100; thus 1200 insects were counted on the tree situated on the northeast corner of the grove; 1100 insects were counted on the fourth tree south of the first, etc.

A contour map of the grove was made to show the variation in elevation throughout the grove. Beginning at the lowest elevation of the grove, arbitrarily designated as 0.0 feet, the higher elevations were successively determined by sighting along a level to the top of a five-foot pole situated at a lower and previously determined elevation. The various elevations throughout the grove are indicated by the contour lines in Figure 63.

Two thermographs were placed in the grove: one at the 40 ft. level and one at the 0.0 ft. level. Figure 64 shows the average temperatures at these elevations from April 17 to May 15, 1932. The average temperature at the 40 ft. level was 4.73°F. higher than that at the 0.0 ft. level.

The greatest variation in temperature occurred at night. During the day the temperatures at the two elevations became more alike, and

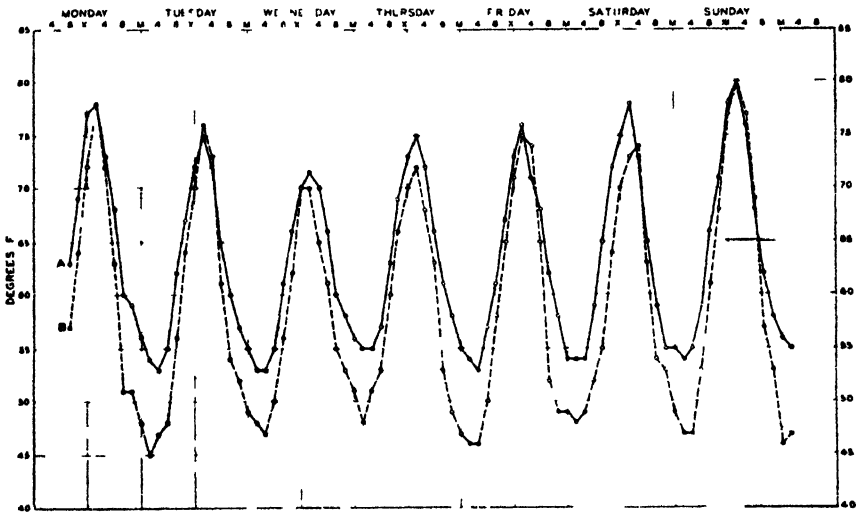

Fig 64 – Chart showing the average temperature over a one-month period at the highest portion (A), and the lowest portion (B), of a hilly lemon grove

in the early afternoon the temperature at the lower elevation was in a few cases higher than at the higher elevation This may be due to the influence of the cool afternoon breeze blowing from the ocean, which affects the higher elevation before the lower, for the lower elevation is bounded on all sides by more elevated land protecting it from the direct influence of the ocean breezes.

Since the grove has received uniform cultural treatment and pest control measures, the density of the red scale population may be assumed to be a function of temperature. Variation in elevation alone, however, may not be the sole factor affecting the temperature of the insects' immediate environment. Thus the hilltops have a shallow and impoverished soil as compared with the lower lands; consequently the trees on the hilltops are smaller and more open than those in the lowlands, and admit more sunlight and afford a warmer environment for the insects occurring on them. The 4.73°F. difference in

temperature between the lowest and the highest elevation in the grove may not in itself be sufficient to cause the differences in population density which were found in the grove.

On the other hand, an impoverished soil may produce trees in such a weakened condition that they are no longer a suitable host for the scales, and in this case a lower population may be found on the small, open trees than on the thrifty trees. As can be seen by an examination of Figure 63, the trees on the northwest corner of the grove at an elevation of 30 and 35 ft, had no more insects per unit than those at the lowest elevation; while the trees at the 30 and 35 ft. elevation in the northeastern section of the grove had several times as great an infestation. It is possible that this may be accounted for by the weakened condition of the trees in the northwest corner, which were on a very steep slope, as the contour map indicates, and were on a very poor type of soil.

The grove considered in the present paper presents a topography rather typical of the Yorba Linda district. Temperature records given to the writer by the owner of another citrus grove in this district show a difference of 6°F. to 10°F., depending upon the humidity, between the lowest and the highest portion of his grove when the trees were being fumigated.

The foothill districts as a whole are considerably warmer than the lowlands, which constitute the major part of the citrus area. For this reason they are largely planted to lemons, which are less frost resistant than oranges. These foothill districts have been called "resistant red scale areas" because of the difficulty encountered in controlling the red scale by the ordinary control measures. While the greater resistance of the strains or races of red scale found in some areas has been demonstrated by Quayle (1922), it is not known to what extent "resistance" as applied to red scale in the foothill districts is due to the higher temperature prevailing in these districts. It is not known, also, to what extent the apparent resistance in these districts may be accounted for by the fact that the lemon is the preferred host of the red scale.

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NATURAL CONTROL OF THE CITRUS MEALYBUG[1]

By F. R. COLE, *Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

The introduction into California of certain natural enemies of the citrus mealybug (*Pseudococcus citri* Risso) has apparently accomplished its control and brought the population to a very low point. The coccinellid beetle, *Cryptolaemus montrouzieri* Muls., and the hymenopterous parasite, *Leptomastidea abnormis* Gir., can be credited with the major part of this reduction of the citrus mealybug. The present paper gives a brief history of the pest in California and some observations on the predators and parasites present during the early outbreaks and continuing up through the year 1918. There is a rather complex interrrelation of the various parasitic enemies, the most important of which are pictured on the accompanying chart.

The citrus mealybug (*Pseudococcus citri* Risso) is now at a very low point in its population, perhaps at its nadir, and it is possible that its role as an important citrus pest is now at an end. On the other hand, it may be a part of a great moving cycle, destined to ascend from its valley to new peaks of importance. Various insects have at times held the spotlight in the history of pest control in California, such as the San Jose scale, the cottony-cushion scale, the black scale (still important), the two mealybugs of citrus, and now the California red scale.

Our earliest references to the citrus mealybug in southern California are concerned with *Pseudococcus citri*, but there was some confusion with *P. maritimus* Ehrhorn, a less abundant species. The citrus mealybug has long been recognized as a greenhouse pest in many parts of the United States, the known records dating back to 1885. In California it was attracting some attention about 1900, becoming a real menace from 1904 to 1910, and constituting a major pest of citrus up to 1930 (*3, 8*). The problem was complicated by the appearance in 1913 of another mealybug, *Pseudococcus gahani* Green, known as the citrophilus mealybug, soon to take front-page notice from the older established *P. citri*. In 1920 *P. citri* was still the most important. Smith and Armitage (*14*) have traced the history of the mealybug in a recent bulletin.

[1]The summarized records given herewith are based in large part on the unpublished laboratory and field notes accumulated by R. S. Woglum while an employee of the United States Bureau of Entomology. The writer was an assistant at Mr. Woglum's laboratory in 1914 and 1915 and is greatly indebted to him for the privilege of examining and making use of these old notes.

Quoting from an old report on *P. citri*, in a bulletin of the Claremont Pomological Club (*15*):

> From close observations in a badly infected district I would say that the mealy bug is by far the most damaging and dangerous pest now in the Southland. I believe that the citrus industry is threatened by the invasion of this insect as it has not been threatetned since the ravages of the *Icerya purchasi*, before it was checked by its natural enemy, the *Novius* (*Vedalia*) *cardinalis*. In prolificness, in endurance to hardships, in power to spread and to do damage no pest in the South is nearly its equal.

This was the opinion of a county agricultural commissioner in which most growers and field men of the period concurred.

In the writer's opinion, which is based in part on observations in 1914 and 1915, credit for control of the citrus mealybug should be given to introduced natural enemies, the most important probably being, as Smith and Armitage (*14*) point out, the beetle, *Cryptolaemus montrouzieri* Mulsant, and the hymenopterous parasite, *Leptomastidea abnormis* Girault. The native predators and parasites have also had a part in this work, but they have been found to be more or less inefficient, principally because of parasites preying upon them. Other, less obvious, biotic factors, as well as climatic changes, may have had some influence on this control.

Cryptolaemus montrouzieri Muls. (named for Abbé Montrouzier by Mulsant) was collected by Koebele in Australia and brought to California in 1892. Mr. Koebele found the beetle preying on mealybugs in Fiji, Ceylon, and southern China. When introduced into California, it found conditions in the coastal area to its liking and was soon a factor in mealybug control in San Diego (*5, 8, 11, 23*); in most cases, however, it required artificial breeding under controlled conditions in order to attain any great numbers. There is some difference of opinion as to the value of these beetles, commonly called "cryps" in the industry, but when reared in insectaries by the modern methods devised by Smith and Armitage, they are unquestionably an important control factor. This beetle has failed to establish itself in Egypt and Palestine, owing largely to climatic factors, as pointed out by Doctor Bodenheimer (*1, 2*). In Palestine it has six generations against eight for the mealybug, and in addition can not survive the cold of winters or the moist heat of the summers. It has a developmental zero of 10.3°C. against 8.4°C. for the mealybug. The beetle lays from 200 to 750 eggs over a period of three to five months; the mealybug averages about 200 eggs. At Pasadena the egg stage of *C. montrouzieri* is

about 5 days, the larval stage 14 days, the pupal stage 11 days. The greatest feeding by the beetle is done in the larval stage, this stage in the 1917 records accounting for from 319 to 407 of the first and second stage mealybugs and from 60 to 71 of the third and fourth stage host. Adult feeding is more limited and has been recorded by various writers.

Leptomastidea abnormis Gir.—There have been some errors in the recording of the first introduction of this species into California. The first specimens of this important little parasite were collected by Prof. H. J. Quayle in Sicily in 1912, some of the original material now being in the United States National Museum collection. Two years later H. L. Viereck, while an agent of the California State Department of Agriculture in Sicily (*19*), collected numerous mealybug masses at Palermo and shipped them out to the State insectary; from this material Harry S. Smith bred out the first of these little encyrtid parasites, then known as *Leptomastix* sp. (*12*). There has been considerable juggling of the species first placed in the genus *Leptomastix*, a genus originally described without designation of species by Foerster in 1856, and about twenty years later established on the genotype *histrio* by Mayr. Howard described *dactylopii* in 1885 from specimens bred from *Pseudococcus citri* in Washington, D. C., and in Grenada, West Indies. In 1887 Ashmead described a third species, *L. tinaevora* from Florida—not a mealybug parasite, however. In 1915 Girault (*9*) made a study of the little Sicilian mealybug parasite and placed it in his genus Paraleptomastix under the species name *abnormis*, In 1918 Timberlake (*17, 18*) erected a new genus, Tanaomastix, with *abnormis* as the type, and included with it the old species *albiclavata* (*Aphycus albiclavatus* Ashmead, 1905, Philippines), together with a California parasite of the cypress mealybug (*Pseudococcus ryani* Coquillett), named *T. claripennis* Timberlake. The little banded-winged *abnormis* now seems to have found a resting place in Mercet's genus Leptomastidea.

Whatever its systematic position, *L. abnormis* has been remarkably effective on *Pseudococcus citri* in California, on which it is almost specific. It does not seem able to breed through on *Pseudococcus gahani* or *P. maritimus* (*4*) and is only occasionally bred from *P. krauhniae* Kuwana. Bodenheimer considers the species too sensitive to climatic factors to be of value in Palestine. In California its developmental period from the start of the egg stage to maturity may range in length from 21 to 49 days, and the adults have been kept alive for 34 days. Un-

fertilized females produce males only, and only one parasite develops from a host, although three eggs may be laid and Armitage and Smith (*13*) have recorded as many as 100 under forced conditions. The mealybug continues to move about until the pupation period of the parasite, at which time the host dies and forms a globular shell, or tunica, about the parasite pupa.

INTRODUCED PREDATORS OTHER THAN CRYPTOLAEMUS.—(*Rhizobius*) *Lindorus lophanthae* Blaisdell, also known in literature as *Scymnus marginicollis* Mann. (*7*) was introduced into California by Koebele, but it was found to have existed in the State long before this. It is of very little value in feeding on mealybugs, being more of a scale parasite, particularly abundant in some areas infested with the red scale.

Scymnus bipunctatus Kugelann was first believed to be (*Cryptogonus*) *Aspidimerus orbiculus* (Gyll.), and was secured by George Compere from the vicinity of Manila in the Philippine Islands. In 1911 and 1912 many colonies of this species were collected and sent out by the State Horticultural Commission, with great hopes for it as a means of controlling the mealybug. Essig published the first complete account of it in 1911 (*6*) from material first put in cages in July, 1910. Insectary tests were promising, but the beetle failed to establish itself under orchard conditions.

Rhizobius ventralis Erichson was introduced from Australia by Koebele in the early nineties as a parasite of the black scale. It was said to be one of the most numerous coccinellids in South Australia and Victoria, occurring in remarkable numbers around a soft scale on eucalyptus. The beetles at Melbourne. Australia, were commonly parasitized by a species of Homalotylus, but these parasites were in turn checked quite efficiently by a secondary. Koebele reported twelve other promising species of Rhizobius from the Australian region, but none has been of importance in mealybug control; one, *Lindorus lophanthae*, is mentioned above.

INTRODUCED INTERNAL PARASITES OTHER THAN LEPTOMASTIDEA.—There have been several attempts to introduce internal parasites of the mealybugs but, except for the Leptomastidea, most of them have been without success, particularly in the case of *Pseudococcus citri*. About 1908 George Compere brought in three then unknown parasites, one of which was recovered by Essig in Ventura County and determined as *Chrysoplatycerus splendens* Howard (*7, 8, 16*). This parasite breeds slowly and is of little economic importance.

NATIVE PREDATORS.—*Hyperaspis lateralis* Mulsant (*7*) is a native

coccinellid found feeding on mealybugs in several parts of the Southwest. The dark beetles are 2 to 3 mm. long, the elytra shining black with three red or pale spots. The white woolly larvae look like those of the Cryptolaemus. The species is occasionally of local importance, the larvae and adults being feeders on various mealybugs, but a parasite of the genus Homalotylus is so abundant as to ruin its efficiency. The length of the egg stage is from 8 to 15 days, that of the larval stage from 15 to 20 days, and that of the pupal stage from 14 to 22 days. The female lays from 50 to 558 eggs. The larvae consume on an average about ten small mealybugs and four of the third and fourth stage per day. The adults eat comparatively few mealybugs.

Scymnus sordidus Horn (*7*) is a small brown ladybird beetle common to most of southern California. It is a fairly effective worker on the mealybug but not a real factor in control.

Scymnus guttulatus Leconte, a black species with reddish markings, was at one time bred in considerable numbers in the state insectary at Sacramento. In 1909 Essig made some trials of about 1,000 beetles in Ventura County with little success, those liberated out-of-doors being lost completely. Essig quotes Casey's description of the beetle, published in 1899 (*6*).

Scymnus nebulosus Leconte has done some effectual work in feeding on the citrus mealybug. The adults are very small beetles, brown, with darker markings. The larvae feed on aphids and scale insects other than mealybugs.

The brown lacewings are important in mealybug control, and are sometimes given credit for being the best of all mealybug enemies, but they are not easily raised in confinement and too many parasites attack them. The three species of *Sympherobius* studied at Pasadena from 1914 to 1918 were *californicus* Banks, *barberi* Banks, and *angustus* Banks. They can be distinguished in all stages and have good larval characters. The sexes appear to be about equal in numbers and the adults live about 10 to 15 weeks. Very few adult mealybugs are eaten by these lacewings, but the first and second stages are consumed rapidly. The adult lacewing eats the whole mealybug, averaging about four per day. It also consumes considerable honeydew.

The egg stage of *S. barberi* lasts about 7 days, the larval stage about 10 to 18 days, and the pupal stage about 11 days. The life history of the other two species, *californicus* and *angustus*, is essentially the same.

The lacewing larvae eat comparatively few mealybugs, but they do

consume many mealybug eggs. For example, 13 larvae of *S. barberi* ate on an average 373 eggs, and during the same period ate on an average 6 of the first and second stage larvae and 0.6 of the third and fourth stage mealybug.

One lot of *S. californicus*, with the larval period extending 13 to 16 days, ate an average of 1,043 mealybug eggs; another lot, with larval periods lasting from 14 to 22 days, ate an average of 864 mealybug eggs. These larvae each ate an average of about 270 small, first-stage mealybugs.

S. angustus is usually less common about mealybug infestations and, from the few records taken, is less efficient as a feeder. An idea of the egg laying of this species may be gained from the following: 379 eggs in 44 days, 86 eggs in 50 days, 610 eggs in 34 days, and 496 eggs in 47 days. From 95 to 100 per cent of these eggs hatched, the egg stage averaging 11 days in summer but lengthening to 33 and 34 days during December and January.

In all the species of Sympherobius there is considerable larval mortality during the early stages, most apparent in the first stage, particularly at temperatures around 95°F. and over. In hot weather the adults and larvae collect on the cool north side of the trees, occasionally getting on the ground on leaves under the trees. The newly hatched larvae may destroy a few of the unhatched eggs near them, usually a very small percentage. A few lots of *S. barberi* had unusual tendencies to cannibalism, sometimes eating as many as 50 per cent of the total hatch.

Bodenheimer (*1, 2*) has made some interesting observations on *Sympherobius amicus* Navas in Palestine. This predator is admirably suited to its habitat and is remarkably effective. Unlike the California species, it has no recorded parasites. It has eight generations, the same as its host, and the average lot of 250 or more eggs usually produces 40 per cent or more of that number of adults.

There are several known parasites on Sympherobius in California, all of them chalcids. Records from the Pasadena laboratory notes taken from 1915 to 1918 show that *Dibrachys daphne* Girault was bred from *S. barberi* and *S. californicus*, and *Dibrachys boucheanus* Ratzeburg from *S. californicus;* there is also a very doubtful record of *Tomocera californica* Howard from *S. californicus*. From *S. angustus* two species of Isodromus were bred, *I. niger* Ashmead and *I. iceryae* Howard, and these parasites also attacked one of the green lacewings (Fig. 65). In spite of this interference by hymenopterous parasites, the brown lace-

wings are always present around mealybug colonies and are sometimes an evident factor in control.

The green lacewings, represented by three species of Chrysopa in Cali-

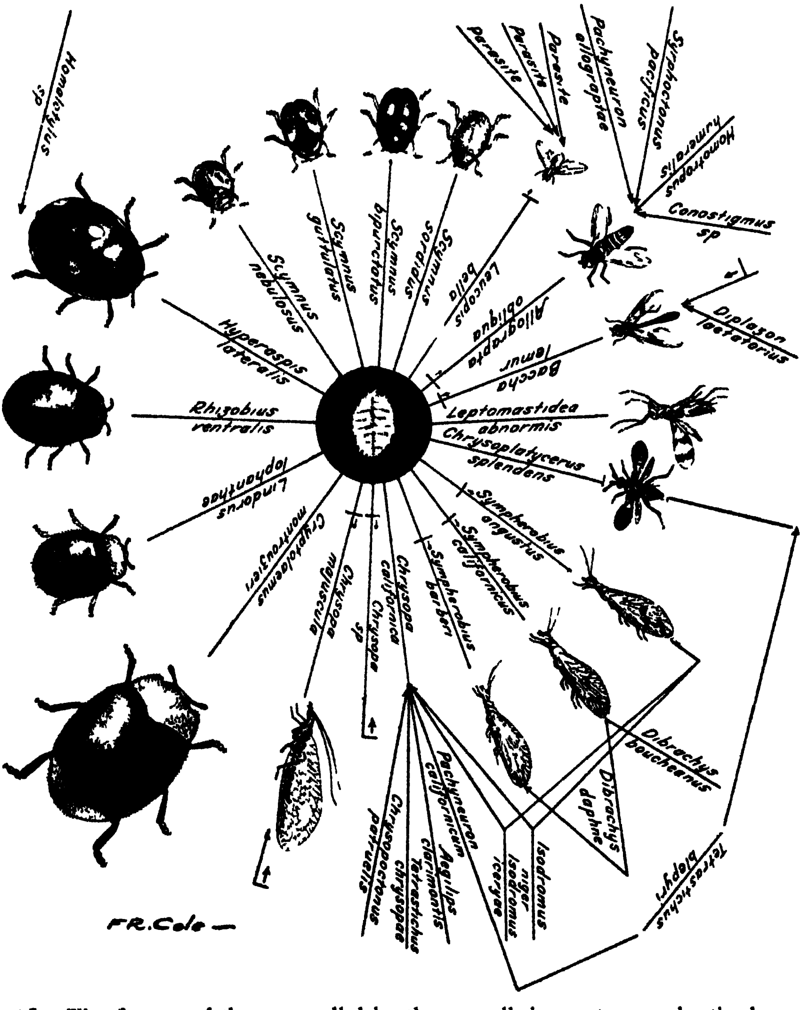

Fig. 65—The figures of the coccinellid beetles are all drawn to a scale, the largest, *Cryptolaemus montrouzieri*, being actually about 3.5 mm. in length The other insects figured are mostly on a smaller scale, the cross lines and arrows indicating the length if translated into the scale used for the beetles

fornia (*20*) show evidence of potential efficiency, but there is too much parasitism by Hymenoptera. The feeding rates on all three species

were recorded at the Pasadena laboratory, and will be given in a later more complete paper. The commonest species is *Chrysopa californica* Coquillett (*20*) and from this no less than six parasites were bred: *Isodromus niger*, *I. iceryae* (common), *Chrysopoctonus patruelis* Cushman, *Tetrastichus chrysopae* Crawford, *Aegialips clarimontis* Kieffer (a cynipid), and *Pachyneuron californicum* Girault; from the last mentioned the common secondary *Tetrastichus blepyri* Ashmead was bred. *T. blepyri* (*18*) is also parasitic on *Chrysoplatycerus splendens* Howard, one of the introduced primaries previously mentioned, so a natural balance is possible. A general collection of green lacewings about mealybug colonies will usually reveal, in addition to *Chrysopa californica*, *C. majuscula* Banks and an undescribed species very near *C. californica*. Studies of all stages of Chrysopa were made at Pasadena in 1915 to 1918.

The larva of the common syrphid fly *Baccha lemur* Osten Sacken is an occasional predator in colonies of the mealybug, but the numbers are usually small and the feeding rate is low. This predator is parasitized by the hymenopteron *Diplazon laetatorius* Fab., which is also a parasite of another syrphid fly predator, the common *Allograpta obliqua* Say (*10*). This other syrphid is of no importance as a mealybug feeder, and would in any case be held down by its parasites, of which there are at least four (*10*) in addition to the one mentioned above—*Homotropus humeralis* Provancher, *Conostigmus* sp., *Syrphoctonus pacificus* Cresson, and *Pachyneuron allograptae* Ashmead.

A small silvery gray fly is nearly always found as a predator in mealybug colonies, more abundant about the citrophilus mealybug than with the *P. citri*. This dipteron, *Leucopis bella* Loew, was considered the most important enemy of the citrophilus mealybug back in 1917 and 1918. It is still a factor in the control of the citrus mealybug. Two unnamed parasites have been bred from *Leucopis bella*.

Woglum and Neüls (*21*) demonstrated the relation of ants to mealybug control about sixteen years ago. These ants, particularly the Argentine ant, not only distribute the young mealybugs on citrus trees, but also keep away most of their natural enemies. The method of keeping ants out of the citrus trees has been discussed in various papers (*22, 23*); suffice it to say that banding with sticky tree-banding material is usually effective, allowing the predators to work on the mealybug colonies unmolested.

Summary.—In summing up the various factors in the natural control of *Pseudococcus citri*, it may be noted that the unimportant *Chryso-*

platycerus splendens is the only actually specific enemy, although *Leptomastidea abnormis* is nearly so, and *Sympherobius californicus* and *S. barberi* are perhaps 75 per cent confined to this host. This means that the insect enemies are not concentrated in their attack, but it also means that the reserve food of other hosts will keep predators and parasites alive when the citrus mealybug is scarce.

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FARM MACHINERY IN RELATION TO INSECT PEST CONTROL

By E. O. ESSIG, *University of California*

ABSTRACT

Regular farm equipment used in plowing, planting, cultivating, and harvesting and special machinery employed in irrigating, leveling, and many other farming practices may contribute considerably in reducing and even in controlling certain insect pests which may be present on the plants, in the stems or stubble, in the seeds or tubers, and in the soil.

Many attachments may also be used on such machinery for the express purpose of destroying insects

Up-to-date modern economic entomology is a many-sided profession. It not only embraces a thorough knowledge of insects, but a considerable amount of intimate information regarding botany, chemistry, and engineering. The relation of farm machinery to insect pest control is becoming increasingly important. This is due to the fact that agricultural engineers are turning their attention to these problems and we are no longer entirely dependent upon the private inventor and manufacturer to fulfill such needs.

There are many insect problems the solutions of which lie in good and timely farm practices and the importance of such practices cannot be overestimated in the present stress of economic conditions. One of the fortunate aspects of such pest control is that the methods employed are also responsible for an increase in yield and a bettering

of the quality of the crop. Thus the most important factor in keeping down such pests as red spiders and thrips is maintaining proper food and moisture conditions in the soil to produce vigorous plants. Such conditions are difficult to secure under dry farming methods but thorough cultivation with proper equipment may greatly aid in conserving the precious moisture which nature gives in sparing quantities. Subsoiling and summer fallow also make their contributions. Irrigated lands often suffer for water because of the character of the soil and improper methods of irrigation. In such cases insects too frequently prove the inadequacy of the practices being followed.

A poorly prepared seed bed often delays germination of potatoes, beans, corn, wheat, barley, and other crops, and affords an opportunity for wireworms, root maggots, cutworms, and other soil infesting insects, to destroy the seeds or the young plants, which might have outgrown their attacks.

Certain types of pruning may open up the trees so as to make it impossible for certain insects to become destructive thereon.

Flooding during the winter has been an economic practice in controlling the garden centipede in the asparagus fields of the delta region, whereas the application of carbon disulfide emulsion has afforded control in greenhouses.

Timing the cutting of the alfalfa hay has a very important effect upon reducing the numbers of alfalfa weevil larvae in a field and close and clean cutting of the crop is also an important factor.

Hilling potatoes may be the determining factor in producing a crop free from the very injurious larvae of the potato tuber moth. Or digging them at the proper time may mean the difference between a clean and an infested crop. Even the thoroughness of removing the tubers from the soil has an important bearing in reducing the seriousness of the attacks of this particular potato pest.

In the recent ten million dollar European corn borer campaign, it was found that certain farm practices could be made far more effective than any other measures of control. Plowing under the corn refuse and other plant debris and the use of huskers and shredders showed the best results and are now generally recommended as the only economically effective methods of dealing with this serious pest.

Burning alfalfa fields for the destruction and control of weeds may also have an important bearing on the insect populations which may be present in the fields at the time.

Many other examples may be cited to show the importance and effectiveness of farm practices in connection with the control of insect

pests. All of these practices depend upon machinery for their execution—the better the implements the more effective the results.

Of course the use of certain specialized equipment such as sprayers, dusters, fumigators, and other devices, play a much more important part in the control of insect pests, but this paper is excluding them in order to emphasize the value of ordinary cultural practices and attendant machinery for a similar purpose.

Agriculture has also reached the stage of specialization which has necessitated mental as well as physical alertness. The growing of a particular crop has become a highly developed art involving a thorough knowledge of many important items. As in all scientific fields, equipment is one of the very important factors which determines success or failure. And I have a feeling that few farmers are aware of the significance of sound cultural practices in relation to the many and varied insect problems which constantly beset agriculture in all its complicated aspects.

Plowing is a necessity in all kinds of farming but the difference between a one-horse plow and a giant tractor beet plow is just one illustration of the many that might be called to mind. In regard to insect pests, plowing has some considerable significance. Deep plowing, in turning under infested plants and stubble, is highly important in connection with the control of the European corn borer, as already pointed out, the Hessian fly, wheat-stem sawfly, wheat jointworm, the larger corn-stalk borer, sod webworms, cotton boll weevil, and many others. Plowing also has an important bearing in the elimination of trap crops, designed to attract insects; cover crops, which may harbor many destructive forms; summer fallow; and clean cultivation. The success of all of these practices is wholly dependent upon the character of the equipment used, therefore the more efficient the equipment the more effective will be the results in destroying the plant materials and the insects which are associated with them.

But plowing does not always satisfactorily complete the task. In many cases where the weeds, refuse, stubble, or cover crop have reached large proportions, it may be necessary to precede plowing with a thorough disking in order to adequately dispose of the materials underground. Or the character of the soil may make it advisable to follow plowing with disking, harrowing, rolling, or dragging. At any rate a first class job is essential. The use of many simple devices on plows, such as cutters, coulters, chains, etc., often play an important part in turning under all surface materials.

One rarely thinks of planting as having any bearing whatever on subsequent insect attacks, but it is certain that too shallow or too deep planting may result in delayed germination and give soil infesting insects such as wireworms, grubs, and maggots, an opportunity to seek out and destroy the seed before it has time to germinate. The quantity of seed sown may also determine the difference between success and failure in the crop. It is often necessary to use much more seed than a good stand requires—the surplus dedicated as an offering to the subterranean pests.

Cultivation naturally follows next. Not only is the removal of weeds often desirable to prevent feeding and breeding places for insects, but the actual stirring of the ground often destroys the larvae and more particularly the pupae of certain beetles and moths. The actual hilling of potatoes is an important practice in excluding the adult potato tuber moths from the soil and results in a much cleaner crop. Cultivation of alfalfa, in connection with the attacks of the alfalfa weevil in the Great Basin area, has proven to be particularly practical in destroying the larvae and pupae of the insect, and adds materially to the quantity and quality of the crop.

Morning glory, a prolific host of red spiders, is often a menace to certain deciduous orchards and vineyards and other weeds and plants employed as permanent ground covers or cover crops may act as reservoirs of thrips, aphids, caterpillars, and countless other destroyers of plant life. It is needless to call attention to the importance of adequate equipment coupled with the determination and endurance of the farmer to eliminate such waste.

Let us now briefly consider some of the methods and machinery used for harvesting the crop. In the case of many products timely and rapid removal from the field is essential to prevent insect contamination. A few examples will illustrate the point. In the case of beans where infestation may occur in the field at harvest time, it is essential to cut, dry, and thresh just as soon as possible. To allow the crop to remain standing one week longer than is absolutely necessary may result in complete infestation by the bean weevil. Improved cutters and combined harvesters have not only made it possible to accomplish these ends, but have also resulted in leaving but a very small proportion of the shelled seed in the field where it may be utilized by the insects for food during the winter.

In connection with the potato tuber moth situation, time and manner of harvesting play an important part. The adults are often very

abundant as the crop ripens and easily make their way around the bases of the dead tops to the tubers upon which they lay their eggs. They also oviposit freely at night on potatoes left exposed on the ground or in sacks in the fields over night. Therefore, the equipment which enables early and rapid removal of the potatoes from the field has a marked influence upon the cleanliness of the stored tubers. Such examples may be multiplied considerably.

Special farm equipment may also play an important part in insect pest control, such as:

1. Insecticide applicators attached to plows, cultivators, and seeders for treating soil-infesting insects.
2. Use of planters and seeders of various types for distributing poison baits to control grasshoppers, caterpillars, beetles, weevils, etc.
3. Light traps to attract and destroy night-flying moths, gnats, beetles, etc.
4. Special harvesting machinery for crushing the plants and thereby killing stem-infesting insects, which would otherwise hibernate in the dried product.
5. Burning equipment for destroying weeds and seeds may affect aphids, and similar insects present at the time.
6. Air sweepers attached to tractors or trucks for capturing flying insects such as the grape leafhopper.
7. For digging trenches and erecting barriers to trap or exclude non-flying grasshoppers, caterpillars, beetles and bugs which often invade cultivated areas in great numbers.
8. For constructing devices to enable flooding to control such a pest as the garden centipede in the asparagus fields of the Sacramento and San Joaquin delta regions.
9. The use of drags, rollers, scrapers, and ground levellers, for crushing insects which have been exposed by the preparation and cultivation of the soil.
10. Special screens to eliminate hibernating insects from products at the time of preparation for shipment. The screening of certain crops for such purposes is occasionally compulsory as in the case of screening potatoes in Idaho to eliminate Colorado potato beetles.
11. Overhead irrigation equipment may have a marked effect in reducing or even controlling such pests as red spiders and thrips, but might actually increase the attacks of aphids, coccids, and other orchard pests.
12. Hopperdozers and other insect catchers for capturing grasshoppers and cutworms in pastures and on forage crops.

INSECTS AND AGRICULTURE

By E. O. Essig, *University of California*

ABSTRACT

Insects often find conditions more suitable for development under modern methods of crop selection and crop specialization than in their natural environment. Thus great areas of single crops have been important factors in the rise of present economic entomology. In order to maintain quality in crop production it is absolutely necessary to continue the present effective program of insect pest control.

Concerning insects and agriculture one often hears such remarks as:

(1. Insects are on the increase.

(2. They are becoming constantly more menacing and injurious to crops.

(3. They are far more difficult to control than in former years.

These assertions though often only casually made are worthy of serious consideration. Is it really true that entomological problems in these modern days are more acute and difficult than of fifty years ago?

The answers to these inquiries are to be found only in unfolding the multiple complexes in the remarkable development of agriculture during the past century. This development has progressed most rapidly in the new world and particularly in areas having a wide range of climatic and geographic features, such as are to be found in California.

It is to be remembered that Old World agriculture lacked most of the present day aspects of this great industry. Farming bore none of the modern ideas of specialization. Farms were small and widely separated; the crops diversified and often rotated; and only those were cultivated, which years or even ages of experience, had proved to be hardy in each particular region. Experimental agriculture was not yet born. There was no exchange of ideas or of plants. Under such conditions insect problems were reduced to a minimum and were accepted as an act of Providence.

The development of new and vast acres of lands revolutionized agriculture. Specialization and experimentation began. In this country potatoes, wheat, corn, apples, and other hardy crops, gradually occupied extensive areas in the central and northern sections whilst tobacco, cotton, rice, sugar cane, and other introduced crops, prevailed in the South. In addition to the staple crops new ones were introduced from the four corners of the world for trial and substitu-

tion, if found promising. Thus we now see vast contiguous acres devoted to a single crop. Who has not been impressed with the unending fields of corn in the great corn belt, or of wheat on the western prairies or of cotton in the South? What pride there is in the potato fields of Maine, the apples of New York, and the beans of Michigan.

California offers a splendid illustration of this new kind of agriculture. Without a single native crop, but with a vast area of untold wealth in soil and climate, it has developed a highly specialized and varied type of agriculture. No less than 180 different crops are produced commercially within the confines of the state. Through a gradual process of adaptation and economic conditions certain areas are largely given over to a single crop or to a horticultural variety. These special areas differ considerably in size but in them the orchards and fields are more or less continuous, without intervening natural or artificial barriers. One cannot traverse California without noting the continuity of many kinds of orchards, of grains and other cereals, vegetables, and forage crops, and countless other forms of plant life. It is not difficult to indicate on a map where each is produced in greatest quantities.

Without attempting to develop this subject further or to go into details regarding the various specializations in crops, which are so well known as to require no further discussion, let us consider the effect of all this in relation to insect pests.

It may seem remarkable to some to know that no cultivated crop is free from insect enemies. In fact practically everyone of them is heir to a score or more depredators and a few are the hosts of legions. Every part of the growing plant, as well as the harvested fruit, seeds, and even the products manufactured therefrom, are subject to infestation and to partial or complete destruction. Certain insects are restricted to specific small or large natural groups or families of plants, whereas others are omnivorous feeders and attack a great and extensive variety. All of the cultivated crops which have been passed down through many generations appear to have always been infested with certain insects and yet new pests invariably appear wherever these plants are introduced into new lands and at times the new invaders appear to be even more destructive than the older ones.

When wheat was introduced into North America by the early settlers, the first destructive pest noted along the middle Atlantic Seaboard was a European insect, the Angoumois grain moth, so

named from a Province in France. However, its injury was small indeed compared with the later inroads of the Hessian fly, another possible European immigrant, and the native chinch bug, both of which found ideal conditions in the extensive wheat fields of the United States and Canada. The potato remained comparatively free from serious insect pests until potato culture spread across the Mississippi River and extended up the Missouri River and Arkansas River valleys to the haunts of the then unknown Colorado potato beetle, which found the potato so superior to the native buffalo bur to its taste and development, that it soon became the most formidable pest of this crop and rapidly spread to every potato patch east of the Rocky Mountains. This rapid natural dispersal was possible because of the almost universal practice of producing potatoes on every farm. But the insect became an economic factor only in those areas where potatoes had become a specialty and were grown in commercial quantities.

Similar instances of the destructiveness of insects may be cited for every crop produced in this and every other country.

To be more specific let us examine the situation here in California.

As already intimated every commercial crop grown in California has been introduced from some other portion of North America, or from some foreign country. Because of our natural resources in soil and climate, it was assumed that plants from practically the entire temperate and subtropical regions of the world could be grown somewhere within the boundaries of the state and many truly tropical plants were also introduced. In the early days before much was known concerning the importance of the insect pests and the methods of transporting them from one region to another, all forms of plant life and insects were freely admitted into the state. And they arrived in every conceivable manner and in every imaginable form, literally from everywhere. This importation of insect pests began in 1769 when the Mission Fathers arrived at San Diego with seeds of cereals and beans infested with weevils. It caused no alarm whatever until almost exactly 100 years had passed when the cottony cushion scale and red scale, began to ravage the citrus and the black scale the olive and citrus orchards of southern California; and the grape phylloxera, the codling moth, and the San Jose scale to infest the vineyards and orchards of northern California. So sudden and severe were the attacks of these pests and so great the losses that immediate steps were undertaken to prevent the further introduction and spread of insect

pests in the state. In carrying out this program much has been accomplished, but we have not yet succeeded in eliminating our entomological problems.

In making a recent survey of the various major insect pests in the state, it was revealed that the greater numbers were of foreign origin. At least 227 different species are immigrants as against some 50 native species.

As a matter of fact the insect pests did not become evident until agriculture had made considerable headway toward specialization when it was both favorable and possible for them to sweep over an area with ease. Climatic conditions and natural barriers have been the only means of staying such dispersals. In view of our present system of agriculture as already described and the general absence of regular crop rotations of any kind, insects are able to become permanently fixed.

The mild even temperatures of the coast are favorable to certain pests, whereas the hot dry summers of the interior valleys favor others. The comparatively warm winters also enable many to persist in great numbers, which might otherwise be killed by snow and ice.

Even though agricultural conditions in California are favorable to insect pests, the latter by no means have a free hand. Pest control in all of its phases has reached a very high state of development here.

The use of fumigants, poison baits, poison sprays, dusts, and other insecticides supplemented by the employment of certain beneficial insect predators and parasites have been most effective and practical. Certain agricultural practices involving many crops have also served to reduce injuries by insects. The exclusion of new pests through quarantine and inspection and the actual eradication of newly established insects are all included in the program of pest control in this state.

There is no doubt but what insects have increased both in abundance and destructiveness during the past century. Their attacks are more regular and constant—and the decidedly higher standards now required for the marketing of fruit and vegetables make commercial control constantly more difficult and expensive.

Insect pests cannot reduce quantity without destroying quality so that in order to have food products of good quality the warfare against them must continue unabated.

A GENERAL METHOD FOR MEASURING INSECT POPULATIONS AND ITS APPLICATION IN EVALUATING RESULTS OF CODLING MOTH CONTROL

By R. E. BARRETT, *Entomologist, Saticoy, Ventura Co. and Moorpark Walnut Growers' Associations*

ABSTRACT

A method of determining insect populations in the field is given which is applicable for many different insects and crops.

Results, expressed as per cent increase between the initial and end populations, are presented for codling moth control on walnuts over a period of five years.

Economic entomological literature is filled with references to control measures in which results are given as per cent insect injured fruit, or other portion of plant, in treated plots in contrast to nontreated plots. Such a method is often employed to express population trends over a period of years. Expression of results by this method especially when different years are under consideration is open to a number of gross errors as only the ratio of occupied to possible occupied host sites is given. As both the population of insects and the number of host sites i.e. yield, vary from year to year and plot to plot, per cent figures give only the ratio between these two variables.

An insect population is but seldom evenly distributed even when relatively small areas are under consideration. It is therefore evident that unless plots are duplicated a number of times or the initial population in each plot is known, end populations will not of themselves give an index of the results of the experiment. When both the initial and end populations are known, any shift in the population density can then be expressed as per cent increase of the population.

The following method, which was devised by the writer to determine field populations and shifts in populations of codling moth infesting walnuts, can be applied with but slight modifications to many different types of work. The percentage of worm injury for each orchard is obtained by cracking and counting the wormy nuts in 100 nuts from each load delivered to the packing house. As no culling is done on the ranches, this gives the per cent of the total crop worm injured for each orchard. The number of wormy nuts in each orchard is determined by multiplying the per cent wormy by the production. In the following tables this figure is given as pounds, but may be converted to individuals by multiplying by 41 (41 nuts = 1 lb.). This will give the number of codling moth in the orchard, as but one codling moth infests a nut in

this region. To obtain the arithmetic mean, M, of the per cent wormy of the orchards under consideration, the pounds of wormy nuts is summed and divided by the total production of the orchards concerned. To obtain the per cent increase in the population, the pounds wormy per acre for the year under consideration is divided by the pounds wormy per acre from the *same* orchards for the *previous* year. When this procedure is followed for two groups of orchards having different treatments, a comparison of the shifts of populations can be made. This determination considers the previous year as 100%, so for example an increase of 75% is to be read as an actual decrease of 25%. This manner of treatment is employed to make minus figures unnecessary.

The probable error of M is obtained in the following manner: M is subtracted from the per cent wormy of the individual orchards, giving a number called Δ, this number is squared to give all plus figures. Number of nuts cracked $\times$ Δ^2 gives a series of figures which are summed and used in determining the standard diviation δ.

$$\frac{\text{Summation nuts cracked} \times \Delta^2}{\text{Total number nuts cracked}} = \delta^2$$

$$\text{Probable error of M} = \frac{\delta \times .6745}{\sqrt{n-1}}$$

Where .6745 is a constant and n the number of orchards considered.

The probable error of the per cent increase in the population is obtained in the following manner:

$$\text{P.E.} = \pm 100 \sqrt{\frac{(A)^2}{(B)^2}\left[\left(\frac{a}{A}\right)^2 + \left(\frac{b}{B}\right)^2\right]}$$

Where $A \pm a$ = lbs. wormy in given year.

$B \pm b$ = lbs. wormy in previous year.

The assumption is made that $r = 0$, this being the correlation between the infestation in a given grove from one year to the next. However the heavier infestations in a given year tend to occur in the same groves as in the preceding year, which would give r a value greater than that assigned to it. This would reduce the probable error of the per cent, increase, hence the error is on the conservative side in assuming that the correlation is zero.[1]

[1]I wish to acknowledge my indebtedness to Dr. C. I. Bliss for calling my attention to this method of solving for the probable error of the per cent increase in the population.

TABLE 1. RECORD OF DUSTED ORCHARDS 1931

Orchards	Production in lbs.	Acres	Hundreds of nuts cracked	Wormy nuts found	Per cent wormy	Per cent wormy × production	Per cent wormy less M = Δ	$Δ^2$	$Δ^2$ × hundreds of nuts cracked
1	7,330	15	4	45	11.25	824	+5.11	26.11	104.44
2	23,155	23.5	8	31	3.87	897	−2.27	5.15	41.20
3	8,103	22	5	47	9.40	762	+3.26	10.63	53.15
4	5,442	10	3	34	11.33	617	+5.19	26.94	80.77
5	6,850	26	4	38	9.50	651	+3.36	11.29	45.16
6	2,589	2	3	9	3.00	78	−3.14	9.86	38.58
7	8,473	18	3	11	3.67	311	−2.47	6.10	18.30
8	69,559	54	13	45	3.46	2,403	−2.68	7.18	93.34
9	50,219	55	9	33	3.67	1,842	−2.47	6.10	54.90
10	28,646	30	7	30	4.28	1,226	−1.86	3.46	24.22
11	21,850	45	7	58	8.27	1,811	+2.13	4.54	31.78
12	68,728	120	15	121	8.06	5,541	+1.92	3.69	55.35
13	962	6	2	4	2.00	19	−4.14	17.14	34.28
14	10,324	39	10	62	6.20	641	+0.06		
15	65,023	55	18	79	4.39	2,853	−1.75	3.06	55.08
16	37,798	35	16	72	4.50	1,701	−1.64	2.69	43.04
17	11,546	10	4	38	9.50	1,090	+3.36	11.29	45.16
18	26,459	38	10	59	5.90	1,561	−0.24	0.06	0.60
19	44,842	37	23	129	5.61	2,513	−0.53	0.28	6.44
20	15,683	14	5	41	8.20	1,289	+2.06	4.24	21.20
21	26,432	21	15	82	5.46	1,441	−0.68	0.46	6.90
22	31,959	38	8	79	9.88	3,159	+3.74	13.99	111.92
23	3,097	17	2	12	6.00	186	−0.14	0.02	0.04
24	34,798	27	10	20	2.00	697	−4.14	17.14	171.40
25	45,414	31	9	51	5.67	2,572	−0.47	0.22	1.98
26	97,190	62	26	271	10.40	10,110	+4.26	18.15	471.90
27	6,252	18	5	45	9.00	563	+2.86	8.18	40.90
28	14,882	20	7	54	7.71	1,148	+1.57	2.46	17.22
29	33,186	38	16	153	9.57	3,175	+3.43	11.76	188.16
30	5,266	10	2	17	8.50	448	+2.36	5.57	11.14
31	75,332	56	24	151	6.29	4,740	+0.15	0.02	0.48
32	26,839	18	7	45	6.43	1,730	+0.29	0.08	0.56
33	37,335	33	17	79	5.64	2,106	−0.50	0.25	3.50
34	20,964	45	12	60	5.00	1,049	−1.14	1.30	15.60
35	30,187	35	11	43	3.91	1,182	−2.23	4.97	54.67
36	16,653	22	9	29	3.22	537	−2.92	8.53	76.77
37	11,795	17	10	72	7.20	850	+1.06	1.12	11.20
38	38,029	43	13	97	7.46	2,838	+1.32	1.74	22.62
39	145,684	167	33	153	4 64	6,760	−1.50	2.25	74.25
40	21,160	25	6	44	7.33	1,551	+1.19	1.42	8.52
41	22,944	28	11	115	10.45	2,395	+4.31	18.58	204.38
42	32,036	29	11	49	4.45	1,426	−1.69	2.86	31.46
Total	1,291,015	1454.5	430			79,293			2372.56

$$M = 100 \frac{79,293}{1,291,015} = 6.142\%$$

$$\delta^2 = \frac{237,256}{43,000} = 5.51768$$

$$\frac{79,293}{1,454.5} = 54.52 \text{ lbs.}$$

$$\delta = \sqrt{5.51768} = 2.3489$$

$$\frac{.00247 \times 1{,}291{,}015}{1454.5} = \pm 2.19 \text{ lbs. P.E.} = \frac{2.3489 \times .6745}{\sqrt{41}} = \pm .247\%$$

Per cent wormy = 6.142 ± .247

Wormy lbs. per acre = 54.52 ± 2.19

TABLE 2. 1930 RECORD TO COMPARE WITH 1931 DUSTED ORCHARDS

Orchards	Production in lbs.	Acres	Hundreds of nuts cracked	Wormy nuts found	Per cent wormy	Per cent wormy × production	Per cent wormy less M = Δ	Δ^2	Δ^2 × hundreds of nuts cracked
1	27,007	15	9	30	3.33	899	+1.69	2.86	25.74
2	77,132	23.5	17	16	0.94	724	—0.70	0.49	8.33
3	35,491	22	13	22	1.69	602	+0.05		
4	13,800	10	4	12	3.00	414	+1.36	1.85	7 40
5	36,190	26	6	20	3.33	1,207	+1.69	2.86	17.16
6	1,968	2	1	4	4.00	79	+2.36	5.57	5 57
7	22,998	18	4	10	2.50	575	+0.86	0.74	2.96
8	119,102	54	15	12	0.80	953	—0.84	0.71	10.65
9	67,440	55	12	22	1 83	1,233	+0.19	0.04	0.48
10	58,906	30	10	9	0.90	530	—0.74	0.55	5.50
11	63,384	45	9	20	2.22	1,403	+0.58	0.34	3.06
12	195,457	120	33	87	2.63	5,150	+0.99	0.98	32.34
13	686	6	2	3	1 50	10	—0.14	0.02	0.04
14	61,447	39	13	30	2.31	1,419	+0.67	0.45	5.85
15	116,718	55	22	23	1.05	1,226	—0.59	0.35	7.70
16	53,681	35	19	37	1.95	1,047	+0.31	0.10	1.90
17	10,283	10	6	19	3.16	325	+1.52	2.31	13.86
18	66,888	38	20	21	1.05	703	—0.59	0.35	7.00
19	78,832	37	22	30	1.36	1,072	—0.28	0.08	1.76
20	14,533	14	6	4	0.67	97	—0.97	0.94	5.64
21	32,861	21	12	16	1.33	436	—0.31	0.10	1.20
22	49,607	38	12	37	3.08	1,528	+1.44	2.07	24.84
23	20,042	17	6	6	1.00	200	—0.64	0.41	2.46
24	62,183	27	14	14	1.00	622	—0.64	0.41	5.74
25	22,388	31	7	5	0.71	159	—0.93	0.86	6.02
26	129,497	62	36	60	1.66	2,150	+0.02		
27	26,180	18	5	12	2.40	628	+0.76	0.58	2.90
28	27,718	20	5	11	2.20	610	+0.56	0.31	1.55
29	53,845	38	20	35	1.75	945	+0.11	0.01	0.20
30	12,481	10	5	17	3.40	425	+1.76	3.10	15.50
31	86,977	56	13	21	1.61	1,400	—0.03		
32	36,136	18	8	8	1.00	361	—0.64	0.41	3.28
33	62,348	33	14	20	1.43	891	—0.21	0.04	0.56
34	67,516	45	22	21	0.96	648	—0.68	0.46	10.12
35	59,639	35	12	16	1.33	793	—0.31	0.10	1.20
36	35,082	22	12	18	1.50	525	—0.14	0.02	0.24
37	22,994	17	11	28	2.54	584	+0.90	0.81	8.91
38	67,694	43	18	30	1.67	1,130	+0.03		
39	204,656	167	31	33	1.06	2,169	—0.58	0.34	10.54
40	46,419	25	9	9	1.00	464	—0.64	0.41	3.69
41	61,921	28	13	26	2.00	1,238	+0.36	0.13	1.69
42	38,077	29	12	32	2.67	1,017	+1.03	1.06	12.72
Total	2,348,204	1454.5	540			38,591			276.30

TABLE 3. SUMMARY OF THE EFFICIENCY OF CONTROL MEASURES 1927–1931

Year and treatment	Acres	Number orchards	Production in pounds	M	δ	Pounds wormy per acre	% increase in population previous year as 100%
1927—Not dusted	154	4	476,069	0.464±0.193	0.4969	14.35±5.96	164.4±86.5
Previous year	154	4	114,708	1.172±0.430	0.9723	8.73±2.82	
Dusted	95	4	241,753	0.695±0.167	0.4287	17.68±4.25	157.9±47.9
Previous year	95	4	69,840	1.524±0.282	0.7247	11.20±2.07	
1928—Not dusted	324¼	6	512,571	1.176±0.207	0.6871	18.54±3.27	122.0±38.0
Previous year	324¼	6	872,911	0.565±0.140	0.4633	15.20±3.77	
Dusted	100	2	210,297	0.855±0.320	0.0478	17.15± 6.74	64.6±35.5
Previous year	100	2	336,573	0.789±0.304	0.4501	26.56±10.22	
1929—Not dusted	771	16	1,899,546	1.156±0.159	0.9107	28.48±3.91	455.0±77.4
Previous year	771	16	1,149,887	0.420±0.039	0.2268	6.26±0.59	
Dusted	649¼	20	1,625,260	0.720±0.063	0.4068	18.02±1.61	101.9±11.3
Previous year	649¼	20	1,002,404	1.146±0.076	0.4938	17.69±1.17	
1930—Not dusted	813	19	1,371,378	1.495±0.109	0.6849	25.22±1.85	205.9±20.7
Previous year	817	19	2,145,112	0.467±0.032	0.2012	12.25±0.84	
Dusted	784½	18	1,034,627	1.245±0.130	0.7966	16.41±1.71	38.1± 5.0
Previous year	818½	18	1,716,117	1.775±0.115	0.7045	43.06±2.42	
1931—Not dusted	1003	33	677,965	7.093±0.443	3.7013	47.94±2.99	646.1±20.6
Previous year	1003	33	1,130,421	0.659±0.052	0.4376	7.42±0.59	
Dusted	1454½	42	1,291,015	6.142±0.247	2.3489	54.52±2.19	205.5±12.5
Previous year	1454½	42	2,348,204	1.643±0.075	0.7153	26.53±1.21	

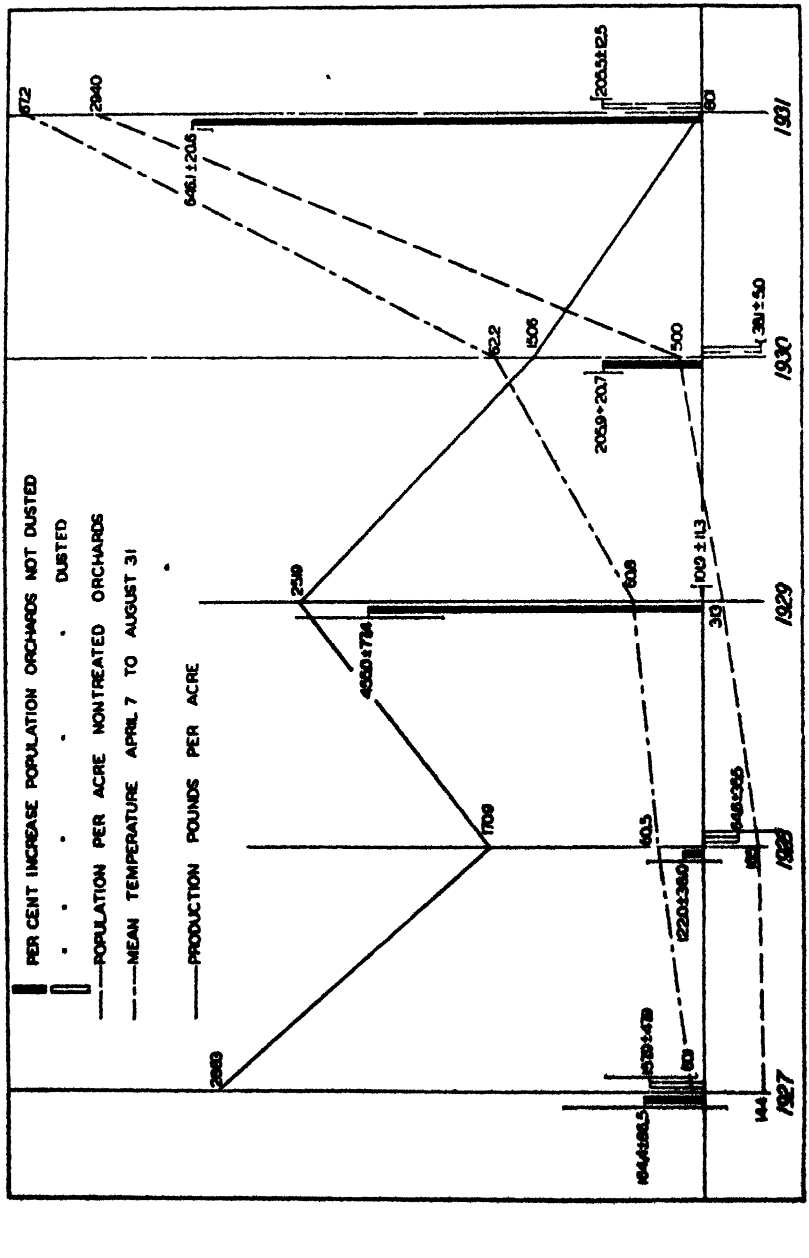

Fig. 66.—Graphic summary of codling moth control 1927–1931

$M = 100 \dfrac{38{,}591}{2{,}348{,}204} = 1.643\%$ $\quad \delta^2 = \dfrac{27{,}630}{54{,}000} = .51169$

$\dfrac{38{,}591}{1{,}454.5} = 26.53$ lbs. $\qquad \delta = \sqrt{.51169} = .7153$

$\dfrac{.00075 \times 2{,}348{,}204}{1454.5} = \pm 1.21$ lbs. $\qquad$ P.E. $= \dfrac{.7153 \times .6745}{\sqrt{41}} = \pm .075\%$

Per cent wormy $= 1.643 \pm .075$
Wormy lbs. per acre $= 26.53 \pm 1.21$

Per cent increase in lbs. 1931 over 1930 $= 100 \dfrac{54.52}{26.53} = 205.5$

P.E. per cent increase =

$$\pm 100 \sqrt{\frac{(54.52)^2}{(26.53)^2}\left[\left(\frac{2.19}{54.52}\right)^2 + \left(\frac{1.21}{26.53}\right)^2\right]} = \pm 12.5$$

Per cent increase in population, previous year taken as 100% $= 205.5 \pm 12.5$

An inspection of the preceding tables will demonstrate the erratic fluctuation of the production and the per cent of the crop wormy. As illustrated in Tables 1 and 2, it would be impossible to obtain an accurate idea of the relative density of population by inspecting the per cent wormy of the total crop.

This general method of determining population shifts can be used only when the population is not so dense that the actual increase is less than the potentional due to the insect being unable to find unoccupied host sites, i.e. saturation point being approached.

Explanation of line in chart marked "Population per acre nontreated orchards." Eight orchards totaling 346 acres were selected in which no control measures had ever been employed. The total pounds of wormy nuts produced each year was computed and multiplied by 41 giving the total population which was then reduced to population per acre. It is of interest to note the close correlation between this line and the mean summer temperatures obtained from readings every two hours.

CASEIN AMMONIA, A PRACTICAL EMULSIFYING AGENT FOR THE PREPARATION OF OIL EMULSIONS BY ORCHARDISTS

By E. J. NEWCOMER, *Senior Entomologist, U. S. Bureau of Entomology*, and R. H. CARTER, *Associate Chemist, U. S. Bureau of Chemistry and Soils*

ABSTRACT

A method is given for the preparation of insecticidal oil emulsions, using casein-ammonia as the emulsifying agent. Laboratory and large-scale tests establishing the practicability and satisfactory qualities of these homemade emulsions are described. Fruit growers in the Pacific Northwest have successfully made and used them in commercial quantity and have thereby effected considerable economy.

Seven or eight years ago, following the introduction of homemade oil emulsions into the Middle West (*1*), a considerable number of growers in the Pacific Northwest made their own emulsions for dormant spraying. The Government formula, calling for the use of soap as an emulsifier, could not be depended on, as the hard water in this region frequently broke down the emulsions made in this manner. Therefore, the Missouri formula (*2, 3*), using casein-lime spreader, was employed. It was indicated by Regan (*5*) in 1926 that this attempt at economy by the growers was not altogether successful. However, the senior author was in the State of Washington during this period and he does not agree altogether with Regan's conclusion that fruit growers can not successfully make oil emulsions. Many of the failures were caused by trying to take unwarranted short cuts, by using old casein-lime spreader, in which the lime had changed to calcium carbonate, or by otherwise failing to follow simple directions. In fairness to the more careful growers, it must be said that many of them did make very satisfactory emulsions, and that a few of them have continued to do so to the present time. Most of them, however, after one attempt, preferred to purchase readymade emulsions, which in the meantime had become cheaper and more readily available.

The authors have witnessed, during the season just past, a return to the homemade emulsions on a basis which has been very successful, and they believe that the methods employed are worthy of notice by entomologists wherever oil sprays are used. Owing to the low price of fruit, growers were anxious to get their spraying done as economically as possible. Accordingly, a group of them in the Yakima Valley conferred with the senior author as to the advisability of making their own emulsions. It happened that a different formula, in

which the emulsifier consisted of casein and strong ammonia, had been used very successfully for three years by the members of the Western Cooperative Oil Spray Project. The senior author therefore suggested this formula to these growers, and both authors have made, under varying conditions, a number of tests of it.

This formula has proved to be very simple and effective, and it has several advantages over the casein-lime formula. The ingredients are cheaper, they do not deteriorate before use, they mix more readily with water, the resulting emulsion is thinner and hence more easily handled, and it may be kept for a number of weeks, as the ammonia acts as a preservative for the casein in addition to making it miscible with water. Credit for having first suggested this method should go to the late Anthony Spuler and to E. L. Green, formerly of the Washington Agricultural Experiment Station, who worked together on oil emulsions in 1928.[1] The original formula, which they never published, called for 6 pounds of casein and about 3½ pints of ammonia, to emulsify 100 gallons of oil, an emulsion containing 75 per cent of oil being made. Experiments by the authors and the practical experience of growers have shown the following proportions to be the most satisfactory:

Oil	100 gallons
Water	33 gallons
Casein (finely powdered)	3 pounds
Ammonia (28 per cent)	1 quart

Some growers have used only 2½ pounds of casein, and good emulsions have been made experimentally with 2 pounds or less, but the cost of the emulsifier is not great enough to warrant taking the chance of reducing it so much. This formula is based on the fact that the presence of ammonia causes the casein to mix, in a colloidal form, very thoroughly with the water. It has been very successfully used with oils for both dormant and summer spraying.

Practical Experience.—Perhaps the best way to describe the method of making the emulsion is to relate how one or two growers proceed who have made large quantities.

Grower A has a 600-gallon portable spray outfit. He puts 132 gallons of water into it, adds 1 gallon of ammonia, and then slowly sifts in from 10 to 12 pounds of casein while the agitator is running. The oil comes in 50-gallon drums, and the grower has provided a 1½-inch pipe which reaches to the bottom of a drum through the large bung in one end. He connects this pipe to his spray pump by means of a

[1]E. L. Green. Correspondence with the writer.

piece of hose, and pumps the oil into the tank with the agitator running. The drum does not have to be lifted, and its contents can be emptied in less than two minutes. When 400 gallons of oil have been added in this manner, a suitable hose is attached to the overflow, and the mixture, which is already partially emulsified by the agitation it has received, is pumped through the overflow into empty drums, under a pressure of 250 pounds, and is ready for use. The whole operation takes about 1½ hours, and requires the services of two men.

Grower B has a 1,000-gallon stationary spray outfit. He usually emulsifies only 100 gallons of oil at a time, using the formula given above. The water, ammonia, and casein are put in with the agitator running, and then the oil is emptied from the drums through the large bung. When it has been added, the mixture is allowed to run through the pump at 250 pounds' pressure, and is sprayed through spray guns into drums. It is then emptied into the tank and again sprayed into drums, thus being completely pumped twice. The whole operation of making the 133 gallons of emulsion takes about one hour and is handled by one man.

From these two examples it is seen that the operation of making an emulsion may be continuous. The agitator should be running when the ammonia is put in, and the casein should be sifted in slowly to avoid lumps. It mixes with the ammoniated water immediately and the mixture does not have to stand. The oil should not be added too rapidly. There seems to be no need to pump the emulsion more than once if it has previously been thoroughly mixed by the agitator, and it may be simply pumped out through the overflow. Table 1 shows that the oil droplets in the emulsion made by grower A were the same size as those in the emulsion made by grower B, and that therefore the two emulsions were probably equally effective. These emulsions have been kept for six weeks or more without deterioration.

Small lots of 20 or 30 gallons for experimental use may be made in the ordinary 200-gallon power sprayer in the manner outlined above, and still smaller lots of a few quarts or gallons are successfully produced by stirring with an electric mixer or pumping with a bucket pump.

About the only danger of failure lies in getting a reversed, or water-in-oil, emulsion, which of course can not be diluted with water and therefore can not be used in that condition. The authors' experiments show that a water-in-oil emulsion usually results from too large a proportion of oil in the mixture, and that, once it has started

to form, it remains in this condition even though the proper quantity of water is added later. If the proportion of oil in the mixture is more than about 85 per cent, a water-in-oil emulsion results. This may be because with these proportions there is too little water to surround all of the oil droplets with a sufficiently thick film of water; the water then becomes the internal phase, surrounded by a much larger volume of oil. An oil-in-water emulsion may be reversed by simply adding oil while it is being stirred. The mixture gradually thickens until the oil content reaches about 87 per cent, when it becomes thin, owing to the formation of the other type of emulsion.

In practice, reversed emulsions apparently result from trying to make too small a quantity in a large tank. If the oil is added rapidly in a case of this sort, the agitator paddles may simply pull small quantities of water up into the oil and form a water-in-oil emulsion. This can be avoided by making a larger quantity or by adding the oil quite slowly until the paddles are well covered. A reversed emulsion need not be discarded, however. If allowed to stand for a time, it breaks down and the free oil may be drawn off and emulsified in the usual manner. Or, a new start may be made with the same quantity of water and emulsifier that was used the first time, and the reversed emulsion added in the same way that oil would be added. This will give an emulsion containing only 60 per cent of oil and due allowance for this should be made when it is diluted for spraying.

The cost of oil emulsions made in this manner is much less than that of the commercially prepared materials. A suitable, finely powdered casein has been available for 13 cents a pound. Ammonia, in 5-gallon lots or less, costs $1 a gallon. Under favorable conditions it does not require more than an hour's time to prepare 200 or 300 gallons of emulsion. Growers estimate the cost of operating the spray outfit at $1 per hour, and satisfactory labor can be obtained for not more than 25 cents per hour. The cost of emulsifying 100 gallons of oil, therefore, exclusive of the value of the oil itself, would be about as follows:

3 pounds of casein	$0.40
1 quart of ammonia	.25
2 men, one-half hour	.25
Use of sprayer, one-half hour	.50
	$1.40

This is not much over 1 cent per gallon of emulsion made, and even under unfavorable conditions, or if small lots are prepared, the cost

need not exceed 2 cents a gallon. This is cheaper than the Missouri formula. The cost of the emulsifying materials alone in the above formula is only 65 cents; the Missouri formula would call for about 12 pounds of casein-lime, which, at the usual price of 12½ cents a pound, would be $1.50.

During the last year growers have obtained oil for dormant use at 14 cents per gallon and for summer use at 21 cents per gallon. The cost of the finished emulsion made from these oils has thus been about 12 cents and 18 cents per gallon, respectively. Commercially prepared emulsions have cost 35 cents and 48 cents per gallon, respectively. The latter contain about 82 per cent of oil and the former contain only 75 per cent of oil, but even allowing for this difference there has been a saving of about 23 cents per gallon on the dormant emulsion and of about 28 cents per gallon on the summer emulsion. The oil used by the growers for dormant spraying has a Saybolt viscosity of about 105 seconds and an unsulphonated residue[2] of about 60 per cent. The oil used for summer spraying has a viscosity of 70 to 75 seconds and an unsulphonated residue[2] of 85 to 90 per cent. These specifications agree with those suggested by the Western Cooperative Oil Spray Project (*4*). A heavy Eastern oil, having a viscosity of 295 seconds, was also used experimentally. This made a very good emulsion, and is evidence that a wide range of oils may be emulsified in this manner.

In 1932 about 45,000 gallons of oil were emulsified by at least 25 different growers. This is sufficient to make about 60,000 gallons of emulsion, or enough to apply a dormant application and several summer applications to 30,000 or 40,000 trees. It is not yet possible to ascertain the total quantity of commercial emulsions sold in the Yakima Valley in 1932, but in 1931 about 725,000 gallons were sold, so that the quantity of emulsion made probably represents more than 8 per cent of the total used. These figures are given to indicate that the statements in this paper are based upon a considerable amount of practical experience. Only two or three growers had any serious difficulty with this formula. One of these failed because he attempted to use casein spreader in place of casein. The others got reversed emulsions, owing probably to an attempt to make too small a quantity of emulsion in a large tank. As these growers were able to reclaim the oil in the reversed emulsions, the loss was very small.

[2]Determined by method 70.5, employed 37 N sulphuric acid and temperature of 100°C. This method is used by the oil companies in California.

The authors are fully aware that growers purchasing oil emulsions from reliable manufacturers may obtain, at no extra cost, considerable service and advice regarding spraying. This is very valuable to many growers, and the authors would be opposed to making a blanket recommendation that all growers attempt to make their own emulsions. However, there are many growers to whom the information supplied by the manufacturers is not worth what it costs, and there seems to be no reason why such growers should not avoid this extra expense.

EXPERIMENTAL WORK.—Experiments were made with several emulsifiers, including milk powder, blood albumin, glyceryl oleate, ammonium linoleate, and lead arsenate. None of these was as good as the casein-ammonia. The milk powder and blood albumin emulsions broke down in a few days, apparently from decomposition of the emulsifier. The addition of ammonia corrected this to some extent. Milk powder is cheaper than casein, but blood albumin costs more. Glyceryl oleate and ammonium linoleate made very good emulsions, but are open to the same objection as is soap; hard water broke these emulsions readily, and even the addition of lead arsenate resulted in some separation of oil. The emulsion made with lead arsenate contained very large oil droplets, and these separated out readily when it was diluted. The average size of the oil droplets in all the emulsions examined is given in Table 1. The oil in these emulsions was of the type used for summer spraying.

The oil droplets in the homemade emulsions averaged three times the size of those in the commercially prepared emulsions, the average diameter of the former being 12 microns, and of the latter, 4 microns Swingle and Snapp (*6*, Table 10), have shown that this difference should not significantly alter the toxicity to the San Jose scale, and the writers' experiments with codling moth eggs do not show any difference in the effect on them. The smaller oil droplets are necessary in an emulsion that is to be shipped and kept for several months, as such an emulsion must be quite stable, but they are not necessary in an emulsion that is to be used by the man who makes it. The homemade emulsions have not caused any more injury than the commercial materials, although they have been quite extensively used, not only by growers, but also by a number of investigators working on the Western Cooperative Oil Spray Project. Either type, if improperly used, may injure fruit trees.

The junior author has examined the deposit of oil left on apples and on glass plates by the two types of emulsion, and he finds that

the homemade emulsion leaves about the same quantity of oil as do the commercial materials. By means of the Gutzeit method he has also determined the quantity of arsenic deposited on apples by lead arsenate applied in combination with various oil emulsions. Samples of apples having equal weights and uniform size were used, and the

TABLE 1. AVERAGE SIZE OF OIL DROPLETS IN VARIOUS LUBRICATING-OIL EMULSIONS

Emulsion	Average diameter of oil droplets *Microns*
Commercial	
Brand A	4
Brand B	4
Brand C	4
Brand D	4
Made by growers	
A	12
B	12
C	12
Experimental[1]	
Casein, 6 pounds (in ammonia)	16
Casein, 3 pounds (in ammonia)	16
Casein, 1.5 pounds (in ammonia)	19
Blood albumin, 6 pounds	23
Milk powder, 6 pounds	40
Glyceryl oleate, 6 pounds	27
Ammonium linoleate, 6 pounds	7
Lead arsenate, 200 pounds	165

[1]Made with small electric mixer. Quantities of emulsifiers given are for 100 gallons of oil.

spraying was very carefully done. Lead arsenate was used alone, at 1 pound to 50 gallons of water, and at the same dilution in combination with the homemade emulsion and with four brands of commercially prepared emulsions. The dilute emulsion contained 0.75 per cent of oil in each case. The quantities of arsenic found were as follows:

	Grain per pound
Lead arsenate alone	0.068
Lead arsenate with homemade emulsion	.072
Lead arsenate with commercial emulsion (average of four brands)	.071

It is apparent that the homemade emulsion leaves a sufficient residue of lead arsenate. All these tests indicate that there is no objection to using the homemade material.

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THE INFLUENCE OF TEMPERATURE ON THE TOXICITY OF CARBON DISULPHIDE TO WIREWORMS[1]

By E. W. Jones, *formerly Assistant in Economic Entomology, University of Minnesota*

Abstract

The relation of temperature to the toxicity of a soil fumigant for wireworms has been shown by means of a diagram. A study was made of the toxicity of carbon disulphide to wireworms at various temperatures when other factors, such as diffusion and adsorption have been eliminated.

The relation of temperature to toxicity has been determined by a method in which median lethal concentrations were the basis of comparison.

The results show that the median lethal concentration of carbon disulphide increases with a decrease in temperature. For every ten degree drop in temperature the concentration is approxmately doubled.

A review of the literature brings to our attention the multiplicity of factors affecting the efficiency of a soil fumigant. The extensive studies of soil from an insecticidal viewpoint, made by Marion (1877), Gastine and Couanon (1884), Blakeslee (1919), DeOng (1917), Leach (1920), Fleming (1923, 1925, 1928) and others, have shown the close relationship existing between the soil composition and condition and the effectiveness of the compound. Of all the physical factors concerned with the toxicity of a soil fumigant, temperature plays a leading role. The relation of temperature to the network of factors influencing the toxicity of a soil fumigant is presented in the diagram (Fig. 67).

Temperature is a factor influencing the physiology and activity of the insect, in turn influencing the rate at which the fumigant takes effect. Likewise, temperature, as it affects the physical processes of fumigated soil, is of chief importance as a factor in limiting the amount of chemical available as a fumigant. This availabilty of

[1]Paper No. 1147 of the Miscellaneous Journal Series of the Minnesota Experiment Station.

fumigant in the soil is in turn a factor in the toxicity of the fumigant. When temperature is lowered there is an increase in absorption and adsorption while, at the same time, loss of water from the soil and the diffusion of the gas is decreased.

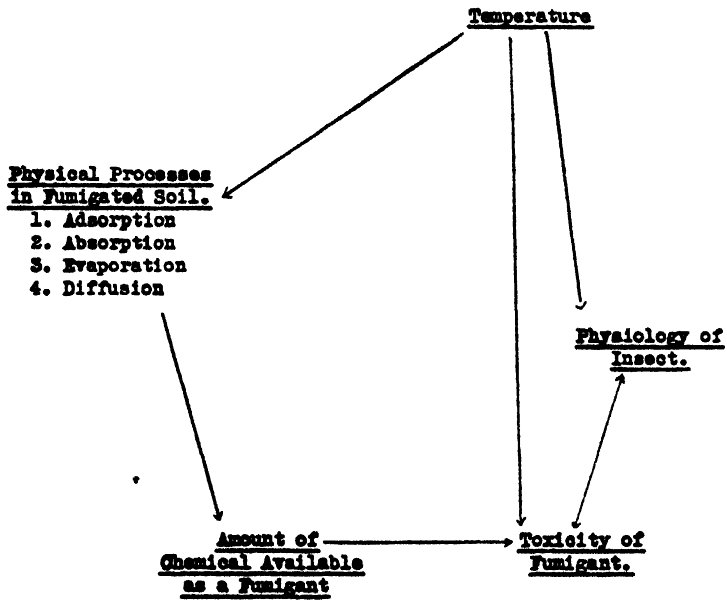

Fig. 67.—Diagram of the role of temperature in soil fumigation.

Only one phase of this relation between temperature and toxicity was chosen to be worked out in this study. Since very little information exists in literature on the relation of various temperatures to the toxicity of soil fumigants, it has been thought worth while to measure the toxicity of carbon disulphide to wireworms at various temperatures when the other factors of diffusion, adsorption, and so forth, have been eliminated. Later, it would be advisable to fumigate wireworms in the presence of soil.

The object of the present investigation was to study the toxicity of carbon disulphide over a series of temperatures (7°, 12°, 17°, 22°, 27°, and 32°C.). The method of determining relative toxicities consisted of measuring those concentrations which kill exactly 50 per cent of the test insects in a period of five hours. These were designated by Strand (1930) as the "5-hour median lethal concentrations." The experiments were performed in constant temperature and humidity chambers at University Farm, St. Paul, Minnesota.

Experimental Methods

Material.—In these experiments wireworms of the genus *Limonius* were used. These were taken from the soil in the summer of 1929 and placed in soil containers in the laboratory at room temperature (20°C.).

The carbon disulphide used was C. P. grade, obtained from the Central Scientific Company, Chicago, Illinois.

Apparatus.—The apparatus within which the insects were actually subjected to the action of the fumigant and which was used within the constant temperature and humidity cabinet consisted essentially of a rubber-stoppered six-liter Ehrlenmeyer flask. A number of flasks were fitted with paraffined rubber stoppers, and each one carefully calibrated. For each flask a special larval-chamber was prepared, which consisted of a small glass vial 30 x 80 mm. fitted up with a screen partition inserted to a depth of 10 mm. below the mouth of the vial.

Procedure.—The actual mode of operation was as follows: Each larval chamber (vial) was partially filled with 10 cc. of water, a necessary precaution to prevent the wireworms dying by desiccation. Twenty wireworms having been placed in each vial above the water, known concentrations of carbon disulphide were put into the six-liter flasks. This was effected by measuring out the liquid from carefully calibrated capillary pipettes each possessing a glass stop-cock. Vials containing the wireworms were then rapidly lowered to the bottom of the flasks by silk cord attached to each vial and the insects allowed to remain in the vapor for a period of five hours. During this time the flask remained in a constant temperature cabinet held at the temperature under investigation. In all cases, previous to fumigation, the larvae and flasks were held at the constant temperature for three hours.

In all experiments temperature of the cabinets was held constant by toluol-mercury thermostats and a hygrothermograph record was obtained. It was found in preliminary work that evaporation had a very important influence on longevity of the insect in a controlled environment out of the soil. By exposing the larvae over small vials of water this factor was controlled. It made no difference whether the relative humidity of the test flask was 30 per cent or 75 per cent. It is well to emphasize the point that the relative humidity was high about the immediate vicinity of the larvae and that the moisture condition thus resembled closely that of the normal soil environment of the wireworm.

After exposure, the larvae were taken out of the flasks and removed from the vials, then placed in closed containers with moist loam soil which were kept at room temperature (20°C.). The per-

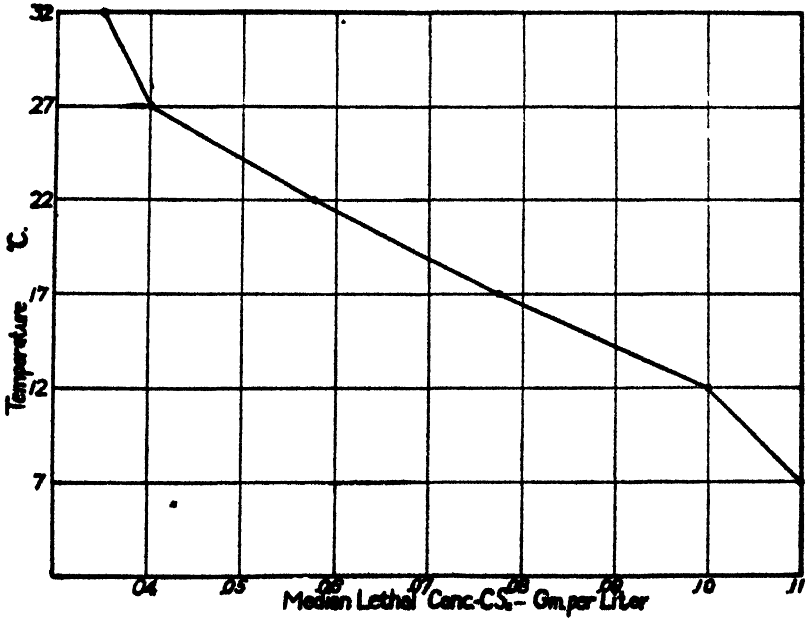

Fig. 68—Curve Showing the Relation of Temperature to the Median Lethal Concentration of Carbon Disulphide for Wireworms

centage of mortality of the fumigated insects was recorded 12 to 24 hours after the conclusion of the experiment and then checked on the second, third, fourth and fifth days. In several lots of twenty unfumigated insects held over the same periods after the 5 hour exposure to temperature in vials there was no mortality. Temperatures investigated were in no case fatal to checks.

The time at which mortality is recorded is important in these toxicity experiments with wireworms. It was noted that as the time interval of checking mortality was increased from 24 hours up to three to five days, the highest per cent of mortality occurred at about three days. However, the policy adhered to in this work was to take the 5-day per cent mortality as the final result of the toxicity of the fumigant.

A series of concentrations for each temperature was tested, in order to obtain progressive increases in the percentage of mortality from zero to near 100 per cent. The results expressed in percentage of mor-

tality have been plotted in the form of concentration-mortality curves. The median lethal concentration for each temperature was obtained by dropping an ordinate line from the 50 per cent point on the curve to the base line where the concentration was read directly.

Results of Experiments

The results with carbon disulphide and wireworms over a series of temperatures are presented in Table 1. The median lethal concentrations and coefficients for carbon disulphide at six temperatures are given in Table 2 (Fig. 68). A temperature of 32°C. was used as the standard.

Table 1. Median Lethal Concentration of Carbon Disulphide at Various Temperatures for Wireworms

CS_2 Conc. gm. per liter	Wire-worms living	Wire-worms dead	Mortality per cent	CS_2 Conc. gm. per liter	Wire-worms Living	Wire-worms Dead	Mortality per cent
	Temperature 7° C				Temperature 22° C		
.04	18	2	10	.02	20	0	0
.08	14	6	30	.04	18	2	10
.12	8	12	60	.06	9	11	55
.14	6	14	70	.08	2	18	90
.16	2	18	90	.12	0	20	100
.20	1	19	95				
.22	0	20	100	.057 M.L.C.			
.11 M.L.C.							
	Temperature 12° C				Temperature 27° C		
.04	18	2	10	.02	20	0	0
.08	16	4	40	.035	13	7	35
.10	10	10	50	.04	10	10	50
.12	8	12	60	.05	5	15	75
.16	5	15	75	.06	4	16	80
.20	1	19	95	.08	0	20	100
.24	0	20	100				
				.04 M.L.C.			
.10 M.L.C.							
	Temperature 17° C				Temperature 32° C		
.02	19	1	5	.02	19	1	5
.04	18	2	10	.03	13	7	35
.06	15	5	25	.04	5	15	75
.08	8	12	60	.05	2	18	90
.12	1	19	95	.06	0	20	100
.14	0	20	100				
.076 M.L.C.				.035 M.L.C.			

Table 2. Summary of Median Lethal Concentrations of Carbon Disulphide

Temperature °C	5 hr. M.L.C.—CS_2 gm. per liter	Temperature coefficient
32	0.035	1.0000
27	0.040	.8750
22	0.057	.6140
17	0.076	.4605
12	0.100	.3500
7	0.110	.3181

The influence of temperature on the median lethal concentration determined in this study of toxicity may be emphasized as follows:

A difference of 5 degrees temperature (1) from 32°C. to 27°C. increases the median lethal concentration only .005 gram carbon disulphide per liter. The successive five degree drops in temperature from 27°C. to 7°C. result in the following increases in the median lethal concentration: (2) 27°C. to 22°C. equals .017 gram or a difference three times as great as a drop from 32°C. to 27°C.; (3) 22°C. to 17°C. equals .019 gram or approximately a difference four times as great as the drop in (1); (4) 17°C. to 12°C. equals .024 gram or approximately five times as great as the drop in (1); (5) 12°C to 7°C. equals .01 gram or a difference two times as great as (1) and less than that of any other of the successive five degree drops in temperature.

A difference of ten degrees (32°C. to 22°C.) resulted in an increase in the median lethal concentration of .022 gram per liter, and the next ten degree drop (22°C. to 12°C.) increased the M. L. C. .043 gram or approximately two times that of (32°C. to 22°C.)

Acknowledgments.—The writer wishes to acknowledge his indebtedness to Dr. A. L. Strand for proposing this problem and for making helpful suggestions as the work progressed.

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FUMIGATION WITH PROPYLENE DICHLORIDE MIXTURE AGAINST *PYRAUSTA NUBILALIS* HUBN.[1]

By C. B. Dibble, *Department of Entomology, Michigan State College*

Abstract

Propylene dichloride mixture used at the rate of two pounds to one hundred cubic feet of space gave a complete kill of European Corn Borer naturally established in sections of cornstalk. The shortest time for positive treatment was found to be twenty-four hours at temperatures from sixty degrees to seventy-eight degrees Fahrenheit, although many borers were killed in an eighteen-hour exposure. This information indicates the possibility of developing a method for treatment of materials (particularly truck-crop produce) prior to movement from infested to non-infested areas.

The number of host-plants attacked by the European Corn Borer (*Pyrausta nubilalis* Hubn.) introduces a serious problem in the movement of plant materials from infested to non-infested areas. This is particularly true with truck crop produce. Celery growers in Michigan were confronted with a quarantine problem in the summer of 1932, and the producers of greenhouse rhubarb face a similar possibility.

In a search for possible means of meeting this situation, preliminary tests were conducted to determine how corn borer larvae could be killed if present in truck crop produce. Contact insecticides as washes proved unsatisfactory, and fumigation was considered. This paper constitutes a report of preliminary work done with fumigants.

The most promising material seemed to be the non-inflammable mixture of propylene dichloride (90%) and carbon tetrachloride (10%). This is commonly sold under the trade name of "Dowfume". A preliminary test run for forty-four hours, using two pounds for each one-hundred cubic feet of space, killed all borers subjected to the treatment.

The strength at which the propylene dichloride mixture should be used was based on previous experiments, but the length of time required to secure a kill remained to be determined and experiments were planned on this basis. The trials were conducted with naturally established larvae of the European corn borer, by collecting cornstalks from infested fields. The infested cornstalks were cut into sections about a foot long, placed in a tight metal container, and fumigated. At the end of the fumigation the treated sections of corn-

[1]Journal Article No. 132 (n. s.) from the Mich. Agr. Exp. Sta.

stalks were spread out on a table for aeration and later the stalks were dissected and the borers removed. Where the examinations were made immediately after the fumigation was completed, it was difficult to separate the living from the dead borers. Death is apparently due to stupefaction and partial paralysis. Where the final counts were delayed until several days after treatment there was little or no difficulty in separating living from dead borers. The treated borers were kept in a warm room and placed in a ventilated mailing tube with corrugated paper, as corn borer larvae will normally spin larval cocoons in this material. Their ability to perform this act after treatment was taken as an indication of survival. Time has not yet permitted a check of the possibility of their completing their life-cycles and reproducing.

Information as to the duration of the various treatments, temperatures, and the results noted are given in the following tabulation:

THE EFFECT OF PROPYLENE DICHLORIDE (MIXTURE) FUMIGATION ON *Pyrausta nubilalis*

Time	Temperature	Dead borers	Live borers	Total borers	Per cent killed	Remarks
44 hours	60–70	53	0	53	100	No life at end of treatment.
24 "	60–70	39	0	39	100	No indications of life to nine days.
24 "	60–70	26	0	26	100	Some life. No establishment to 12 days.
18 "	60–70	28	6	34	82.5	Some partly paralized. No establishment.
6 "	60–70	7	12	19	36.8	Active after six days. Some establishment in paper.
3 "	60–70	10	25	35	28.5	Active after six days. Some establishment in paper.
24 "	76–78	25	0	25	100	Some life. No establishment to twelve days.
18 "	76–78	8	18	26	30.8	One capable of locomotion. No establishment.

It is probable that some borers were killed by slight injuries in handling and counted as killed by the treatment. This has little influence on the data, for with the longer periods of time all borers were dead after treatment. Little difference is noticeable between the lower and the higher temperatures for the effective time periods, except that the paralysis was apparently more pronounced at the higher temperatures in some instances.

The preliminary treatment of forty-four hours gave a perfect kill. The twenty-four hour treatments were also satisfactory. The effect was not so immediately apparent, as some borers retained indications

of life for a short time, but could not perform ordinary life processes. This seems to be the shortest positive period of exposure in these tests, as all shorter periods failed in some instances to give total kills.

A period of eighteen hours exposure gave promising results, but many borers recovered from the stupefying effects of the treatment and some recovered their powers of locomotion. None established themselves, however, in the corrugated paper. It is possible that this exposure would be an entirely satisfactory treatment under all ordinary conditions as it is doubtful if any of these larvae would be able to reproduce. There is a reasonable doubt on this point, however, and the more positive action of the twenty-four hour treatment indicates its definite superiority for the slightly longer exposure.

All tests of less than eighteen hours duration were unsatisfactory. The borers came out of the treatment in a stupefied condition, but all uninjured larvae apparently recovered completely. Many larvae from both the three and six hour tests remained active at the end of six days and established themselves in the corrugated paper.

SUMMARY.—Propylene dichloride mixture, a non-inflammable fumigant, killed corn borer larvae in cornstalks. The material was used at the rate of two pounds to one-hundred cubic feet of space and, although an eighteen hour exposure killed many borers, a twenty-four hour exposure seems to be the shortest positive treatment under ordinary conditions.

A PRECISE METHOD FOR DETERMINING THE TOXICITY OF MIXED GASES TO INSECTS[1]

By R. M. JONES, *Investigator, Crop Protection Institute*

ABSTRACT

A precise method is described for determining the toxicity of mixtures of carbon dioxide and other gases to insects. The principle underlying the method is the introduction of the vapors of volatile fumigants into a partially evacuated fumigation flask, the amounts being measured by means of a mercury manometer. The fall of the mercury in the manometer is proportional to the con-

[1]This report constitutes a part of the research program of The Liquid Carbonic Corporation, Chicago, Ill., which is being conducted under the supervision of the Crop Protection Institute at Iowa State College, Ames, Iowa. The writer wishes to express his appreciation to the above organizations and to Dr. C. H. Richardson, Department of Zoology and Entomology, Iowa State College, for suggestions at various times.

centration of the gases in the fumigation flask. Air is then allowed to flow in until the mixture within the flask is reduced to atmospheric pressure. The details of the method are given and the apparatus is figured The literature on methods for the determination of the toxicity of fumigants to insects is discussed briefly

The use of mixed gases for controlling insect pests in stored products has increased rapidly during the past several years, largely as a result of certain observations made by Brinley and Baker (*3*), in 1927, and by Hazelhoff (*8* and *9*), in 1926 and 1928. The first investigators report that a small amount of methyl acetate seems to increase the toxicity of liquid hydrocyanic acid gas, by keeping open the spiracles of certain insects. Hazelhoff states that one may be able to accelerate the penetration of respiratory insecticides into the tracheal system by the addition of small amounts of carbon dioxide, thus increasing the effectiveness of a given concentration of a gas. Considerable experimental work along this line has been conducted by investigators in the U. S. Department of Agriculture (*2*, *5*, *6* and *7*).

Further investigations on gaseous mixtures by Jones and Kennedy (*11*), Mackie (*14*, *15* and *16*) and Jones (*12*) have shown that carbon dioxide may be used to advantage in reducing the inflammability of certain fumigants.

The use of carbon dioxide in admixture with fumigants therefore has a two-fold purpose; (1) to increase the effectiveness, and (2) to remove the fire-hazard of those which are inflammable and dangerous to use.

The method described in this paper was developed especially for investigating the toxicity of various fumigants in combination with carbon dioxide. A number of experiments have been completed, but will be reported in a separate publication.

METHODS PREVIOUSLY USED.—The methods for determining the relative toxicity of fumigants to insects have, in general, followed two separate lines; (1) the use of glass flasks as fumigating chambers, into which the fumigant is measured by means of small graduated pipettes, and (2) the use of flow meters to measure the concentration of the gaseous insecticide.

Method 1 referred to above has been employed by a number of workers (*4*, *10*, *18*, *19*, *20*, *21*, *25*, *26*, *27*, *28* and *29*) for conducting tests on the toxicities of various compounds to a variety of insects. These studies have for the most part, however, been confined to the use of single gases.

An improved fumigation flask designed recently by Dr. A. L.

Strand, of the Montana State College, was used by Lindgren and Shepard (*13*) in their studies on the influence of humidity on the effectiveness of certain fumigants against the eggs and adults of the confused flour beetle (*Tribolium confusum* Duv.). This apparatus consisted of a 6.2 liter Erlenmeyer flask, closed by a ground glass fitting. Two tubes provided with stopcocks were fused into the glass stopper. The one through which the fumigants were introduced projected a relatively short distance into the flask. The other tube reached nearly to the bottom, thereby increasing ventilation when the flask was flushed by a stream of air. The fumigants (chloropicrin, ethylene oxide and carbon disulphide) were measured volumetrically with pipettes graduated to 0.01 cc.

The only references the writer has found in the literature describing a method for the use of mixed gases are those by Cotton and Young (*5*), Cotton (*4*) and Brinley and Baker (*3*). Brinley and Baker make use of the flow meter type of apparatus and their paper will not be discussed here. Cotton and Young state, "the carbon dioxide was run into the flasks first and allowed to stand a few minutes before the fumigant was added." No further description is given in regard to the technique used in measuring the quantities of carbon dioxide into the flasks.

The apparatus described by McClintock, Hamilton and Lowe (*17*), in 1911, is similar in principle to that discussed in this paper. A partial vacuum was drawn in a large bell jar by means of a suction pump, the pressure being recorded on an attached manometer. The compounds to be used in the tests were placed in a flat brass dish, over which was fitted an inverted glass funnel. Heat was then applied. When vaporization commenced a stopcock was opened and the vapors were allowed to enter the bell jar. The gases were introduced into the jar after the mercury in the manometer had reached a height of about 680 mm., and the vacuum was then reduced to atmospheric pressure by air.

The use of flow meters (Method 2) to measure the concentration of gaseous insecticides was apparently first advocated by Neifert and Garrison (*22*). This type of apparatus was later employed by Neifert, et al (*23*), Brinley and Baker (*3*), Allison (*1*) and Richardson and Haas (*24*) for investigations on the toxicities of various compounds.

Some of the methods referred to above for determining the relative toxicities of fumigants to insects are admirably suited to the use of single gases, with air as the component part. However, as the

review of the literature shows, no accurate method has been described for determining the toxicity of a combination of gases, particularly if one of the compounds is a liquid and the other is a gas at ordinary temperatures. Due to the increasing popularity of the carbon dioxide and fumigant mixtures for commercial use, it seems desirable at this time to place in the entomological literature a precise method for determining the toxicity of these mixed gases to insects.

DESCRIPTION OF APPARATUS.—In this type of apparatus, the depression of the manometer is used as a measure of the quantity of the fumigant in the balloon flask. The apparatus is first calibrated by breaking a number of small ampules containing different weighed amounts of the fumigants in the flask after the apparatus has been evacuated. The fumigants vaporize almost immediately in the partial vacuum, resulting in a definite depression of the mercury in the manometer. When plotted as milligrams of fumigant against manometer depression these experimental values assume a straight line. The fall of the mercury in the manometer necessary to represent the desired quantity of the fumigant is obtained by reading directly from the graph. As the volume of the flasks used was 5.73 liters, then 286.5 mg. (5.73×50) would be required to give a concentration of 50 mg. per liter. By reading across on the graph, one can readily determine the number of millimeters the mercury should fall to indicate the above quantity, which in the case of carbon disulphide would be 12.6 mm. The desired amount of the carbon dioxide is then admitted in a similar manner. The straight line graph for carbon dioxide was calculated from the carbon disulphide graph, by the difference in the respective molecular weights. The percentage of the gases in the flask may be determined by dividing the fall in millimeters of the mercury by the prevailing barometric pressure.

A diagrammatic sketch of the apparatus for determining the toxicity of mixed gases to insects is shown in Figure 69. The set-up consists of a 5 liter Pyrex balloon flask *A*, closed with a ground glass fitting *B*, and sealed with a very small amount of stopcock grease or DeKotinsky cement at *C* to make an air-tight joint. The flask arrangement is connected to the filling assembly by a ground glass joint at *D*. The fumigant is contained in the small 25 cc. flask *E*. Two glass tubes, *F* and *G*, were fused into the glass top of the flask. An insect cage of bolting cloth was attached to the shorter of the two tubes. This tube was closed off by a ground glass cap at *H*. A manometer was attached to the side tube *I*.

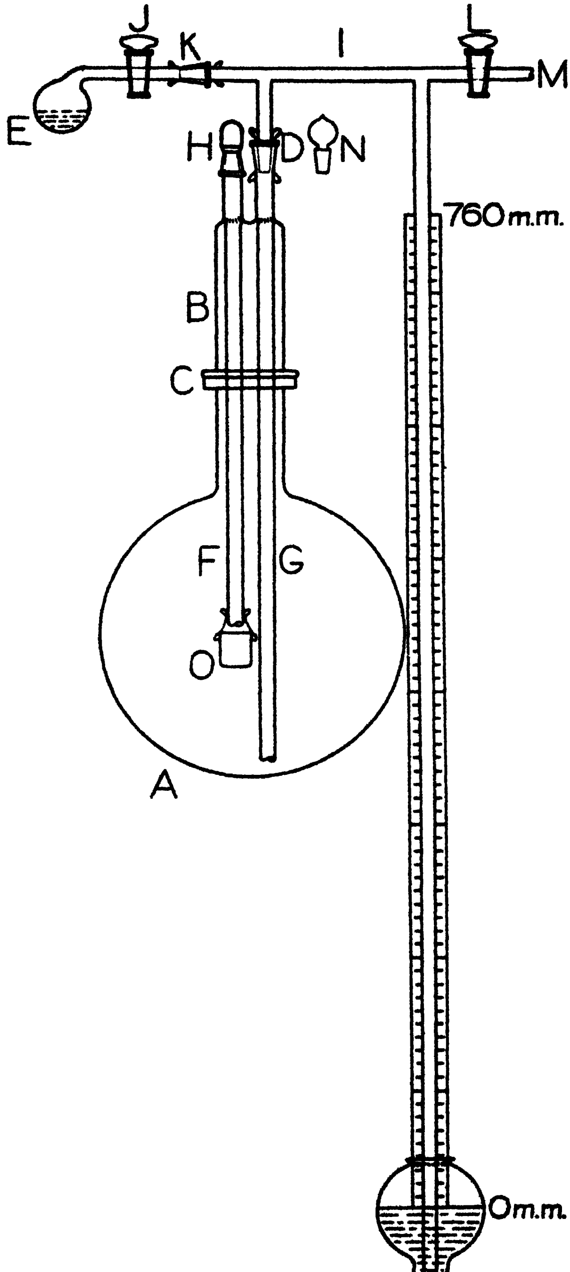

Fig. 69.—Diagram of apparatus used for determining the toxicity of mixed gases to insects.

PROCEDURE.—Before the balloon flask is connected to the filling assembly, the small fumigant flask *E* is filled with the compound to be tested, and is freed of air by either one of two methods; (1) by warming the flask slightly over a low flame until the air is displaced by the vapors of the fumigant, or (2) by closing off the tube at *D* and evacuating until the mercury has reached a height of about 700 mm., after which stopcock *J* is opened until the air is drawn out. Stopcock *J* is then closed, the flask containing the fumigant is disconnected at *K* and air is pulled through the side tubes until all traces of the vapors of the fumigant are removed. Flask *E* is then replaced. The second method was usually followed. The balloon flask is then connected to the filling assembly by the ground joint at *D* and the suction-pump is started. When the mercury has reached a height of about 600 mm. stopcock *L* is closed and the pressure tubing from the suction-pump is removed from tube *M*. The rubber hose from the carbon dioxide tank is then connected to tube *M*. Stopcock *J* is then opened slightly and the vapors of the fumigant are slowly admitted until the mercury has fallen the calculated number of millimeters, after which the desired amount of carbon dioxide is admitted through stopcock *L*. The rubber hose from the carbon dioxide tank is then disconnected from the tube *M*, and air is allowed to enter through stopcock *L* until the mixture within the large flask is reduced to atmospheric pressure. This stopcock is then closed. The balloon flask and its fittings are then disconnected from the filling assembly at the ground joint *D* and quickly stoppered with an interchangeable ground glass plug *N*. The ground glass cap at *H* is then removed and sample of 50 adult *Tribolium confusum* is dropped through the glass tube into the insect cage *O*, after which the cap is quickly replaced. This operation requires but an instant and introduces no appreciable error in the concentration of the gaseous mixture.

The apparatus described above was designed with the idea of using the vapors of the fumigant, instead of the liquid compound, but its use as such is limited to fumigants that have relatively low boiling points and correspondingly high vapor pressures. Fumigants with boiling points below 60°C. may be employed quite satisfactorily in the apparatus, but experience shows that compounds boiling above 70°C. do not have sufficient vapor pressure to be measured accurately by this method. However, the usefulness of the apparatus as a fumigating chamber for compounds boiling at higher temperatures is not impaired by the condition stated above. The liquid compound may readily be measured into the flasks with graduated pipettes, after the desired amount of carbon

dioxide has been admitted. Tests on *Tribolium confusum* with several low boiling compounds showed that the toxicity of a definite concentration of a fumigant was about the same whether the vapor or the liquid was measured into the flask.

The apparatus is somewhat costly, but this is offset by (1) the low cost of operation when using expensive compounds, and (2) the rapidity of making determinations. It is possible to have any reasonable number of flasks constructed to use with the one filling assembly, by having interchangeable ground joints at the connection *D*.

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INVESTIGATION OF NAPHTHALENE AS A FUMIGANT AGAINST THE PEACH TREE BORER, *AEGERIA EXITIOSA* SAY AND SOD INSECTS, A PROGRESS REPORT

By J. R. Stear, *Koppers Research Corporation, Ligonier, Pa.*

Abstract

Present status of investigations with naphthalene as a fumigant against peach tree borers and sod insects, is discussed.

During the past year the writer has carried on a number of tests with crude and refined naphthalene as a control for the peach tree borer. *A. exitiosa* Say, and with refined naphthalene as a control for various sod insects. Due to economic conditions this work has been discontinued and for fear it may not be resumed in the near future, this paper is submitted on the present status of the investigations.

Work with the Peach Tree Borer.—From the beginning of the work with toxic gases against the peach borer, naphthalene has been tested for its possible value. These tests showed naphthalene to be so slightly volatile under the conditions of use that toxic concentrations could not be secured with mound treatments. Blakeslee (*1*) and Peterson (*2*) both report naphthalene as ineffective. Apparently no injury to peach trees treated with naphthalene was observed by either worker.

During the summer of 1931, the writer began a series of tests on two year old Elberta and Hale trees. Crude and refined naphthalene were used at the rate of one-half ounce per tree. Three methods of mound application were used. In one series the materials were heaped directly about the bases of the trees. In the second series the material was scattered from the base of the tree to a distance about two inches away from the tree. In the third series, ring applications, one to two inches from the trees were made. All applications were covered over with a mound of earth. Treatments were left on for two weeks, four weeks, eight weeks and some were left on for almost a year.

Since no borers were present in the trees no control data was secured. It was determined, however, that applications made in contact with the bark cause gumming and dead areas in the bark. This was slight in the case of two weeks exposure but four and eight weeks exposure cause considerable injury. When applied in a ring one to two inches from the tree no injury developed from two, four and

eight weeks exposure and only slight injury after 11 months exposure. Under all conditions, the crude naphthalene appeared to be more toxic than the refined.

Since naphthalene volatilizes so slowly, it occurred to the writer that if naphthalene were placed about the base of the tree at the beginning of egg deposition or hatching and not mounded over, it might remain in position during the effective period and prevent the entry of the larvae into the trees. On August 13th, 1931, Elberta and Hale trees, two years old, were treated with crude and refined naphthalene at the rate of one-half ounce, one and two ounces per tree. The ground at the bases of the trees was not disturbed in any way by the treatment. The materials were simply heaped against the bases of the trees and left uncovered. Two weeks after treatment, an infestation of borers was secured by pinning cards, bearing about twenty borer eggs, on each of the trees. Later examination showed that 98% of the eggs had hatched.

No check was made until early in March, 1932, when a number of the trees were examined. The results are given in the following table.

TABLE SHOWING EFFECT OF NAPHTHALENE IN PREVENTING ENTRANCE OF PEACH BORER LARVAE

Variety	Naphthalene	Amount per tree	Number of borer eggs	Number of larvae found
Elberta	Refined	½ ounce	20	0
"	"	1 "	20	0
"	"	2 "	20	0
"	Crude	½ "	20	0
"	"	1 "	20	0
"	"	2 "	20	0
"	Check		22	3
"	"		27	5
Hale	Refined	½ ounce	20	0
"	"	1 "	20	1
"	"	2 "	20	0
"	Check		27	7
"	"		19	2

The control results appear promising but injury resulted from all treatments. This was shown by gumming and dead spots in the bark at and below the level of application.

Further work planned and under way but discontinued, included a study of the effects on older trees of direct applications; the amount of naphthalene necessary to last during the period of larval entry; the effect of diluents such as earth and sand on the toxicity of naphthalene to the borers and the trees; and the effect of diluents on bacterial decomposition of naphthalene. Since naphthalene costs less

than a third as much as paradichlorobenzene at present quotations and since surface applications would greatly reduce the labor cost. the matter seems well worth further investigation.

EFFECT OF NAPHTHALENE ON SOD AND ON SOD INSECTS.—It recently occurred to the writer that naphthalene might perhaps be effective in lawns and golf greens against such insects as webworms, cutworms, etc.

During the summer of 1932, preliminary tests were carried on to secure information on this question. Treating grass areas with pyrethrum solution showed no webworm infestation at Ligonier, Pa., where this work was carried on, but treatments were made to secure data on toxicity to other insects and to grass under various conditions.

A Kentucky blue grass lawn in fair condition was selected for treatment. It contained considerable white clover, some dandelion and plantain. Plots four feet square were marked off and treated with refined chip naphthalene at the rate of 200 pounds, 400 pounds and 600 pounds per acre. Three series of treatments were made. In one series the naphthalene was broadcast and left as it fell. In a second series it was broadcast and brushed in with a broom. In a third series it was broadcast and washed down with water by means of a sprinkling can. The weather on the day of treatment and for several days thereafter was noted as clear and hot, the temperature during the day running from 75 to 85 degrees.

An examination of the plots 72 hours after treatment showed no injury to the grass nor to the broad and narrow-leafed plantain. Dandelion leaves were scorched and the white clover was killed. Observations at intervals for 30 days after treatment showed no injury to the treated grass. It looked as well as or possibly a little better than the untreated areas though all areas suffered from drought. Dandelion quickly outgrew its injury but the white clover did not recover.

The day following the application of naphthalene, wireworms and cutworms were placed in small individual shell vials, the mouths of which were closed with cheesecloth. The rest of each vial was covered with tinfoil to cut down the effect of sunlight. At 11 A. M. with an air temperature of 80 degrees and a temperature of 81 degrees at the base of the grass, the vials with insects were laid on the ground at the base of the grass. Upon examination, three hours later, all of the larvae were dead in the 600 pound plots, 66% were dead in the 200 pound plots and all were alive and active in the checks. No

larvae were placed in the 400 pound plots. No recovery occurred. As between the different methods of application it was not determined that any method was superior to the others. It would appear then that broadcasting without brushing or washing down with water would be satisfactory.

In a recently cut-over hay field, a small plot was treated at the rate of 600 pounds per acre. Examination three days later showed many dead ants, Carabid and Staphylinid beetles and leaf-hoppers.

The method appears promising and worthy of further trial in web-worm areas and on other species of grass.

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A NEW METHOD FOR COLLECTING SAMPLES OF INSECT POPULATIONS

By Orin A. Hills, *Junior Entomologist, U. S. Bureau of Entomology*

Abstract

A new type of sampler for determining insect populations on wild and cultivated plants has been developed and is described. This sampler provides an accurate means of counting all the insects present on the plants growing on 1 square foot of ground. A suction pipette and a portable, electric, vacuum collector for collecting small insects from the sampler are also described.

A common method of sampling populations of insects on vegetation has been the "sweeping" method. In this a definite number of sweeps are taken over the plants with a standard-size insect net, and the results expressed in terms of the number of insects per sweep or per 50 or 100 sweeps. This method when used in population studies of the beet leafhopper has usually been supplemented in late fall and early spring by counts of the insects occurring per unit area. These counts are made by careful observance of the insects disturbed when examining the area on the hands and knees. Counts of this kind are possible only when host plants are small and when temperatures are low enough to cause the insects to become more or less sluggish. These methods have the disadvantage of producing results that are not directly comparable throughout the season. Also, temperature has a considerable effect on the activity of the insects, and other factors such as wind velocity and condition of the plants must be taken into consideration with the sweeping method.

At Hermiston, Oreg., studies of the beet leafhopper, *Eutettix tenellus* (Baker), and of the insects associated with it on both wild and cultivated hosts have been conducted as a part of the sugar-beet insect project of the Bureau of Entomology. Here populations of these insects are often so high that hand-and-knee counts are not possible, and sweeping is not practicable, owing to the small size of the plants and the comparative inactivity of the insects, due to low temperatures. The method herein described makes possible accurate counts of the insects on a square-foot basis whenever temperatures are high enough to cause slight activity. Thus counts from early spring, throughout the summer, and to late fall are directly comparable. Since the sampler covers only a single square foot, a number of samples must be taken in order to obtain an accurate average.

THE SQUARE-FOOT COUNTING CAGE.—The principal part of the equipment consists of a cylindrical cage mounted on a 4½-foot pitchfork handle (Pl. 40, Fig. 1). By means of the long handle the cage can be suddenly set in place over the plants. Since the cage must be set down forcibly so as to sink into the soil enough to provide an insect-tight seal, the frame of the cage must be very durable to stand the continual shock and yet light enough to facilitate easy handling.

The frame consists of two circular bands 13.56 inches in diameter (inclosing 1 square foot) connected by four 20-inch uprights welded to these bands. The top band is made of ⅛-inch by ¾-inch strap iron, the bottom of ⅛-inch by 1¾-inch iron. The lower edge of the bottom band is ground to a knife edge so that it will easily sink into the soil. About one-half inch down from the top edge of the bottom band small holes are drilled about one-half inch apart to permit sewing the cloth cover to the band.

The handle is attached to the lower band by means of a ⅜-inch bolt inserted into the end of the handle and through a hole in the band. The bolt is held securely in the band by a nut inside and one outside of the band. Experience has shown that an ordinary bolt will not serve here, as the ordinary bolt metal is soft and will bend easily, and also it tends to turn in the fork handle. This was overcome by using a square piece of key steel rounded and threaded on one end to receive the nuts. A wire brace from the top band to a screw eye in the handle greatly strengthens the cage.

The sides of the cage are covered with a good grade of sheeting. This material has been found most practical because of its durability, and at the same time it is thin enough to admit light. The top of the

cage is of canvas in which is sewed a piece of heavy transparent celluloid. This top is made removable, in order to facilitate counting when insects are inactive, by attaching the canvas to a light metal hoop which has been cut and the ends arranged to be drawn together with a thumb screw (*a*, Pl. 40, Fig. 1). The hoop, with the top attached, can be clamped in place around the top band by tightening this screw. The bottom of the cage is of course left open, but is closed by the soil when the cage is in place.

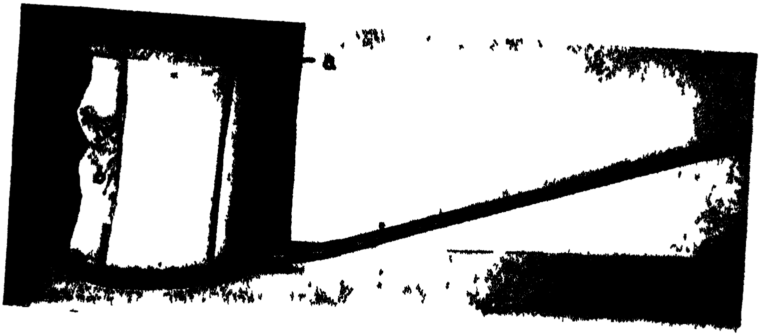
In the side of the cage opposite the handle a hole about 6 inches in diameter is cut and fitted with a sleeve about 1 foot long. The end of the sleeve is equipped with an elastic band. This sleeve permits the operator to insert one hand into the cage, and with the elastic band tight around the wrist there is no danger of the insects escaping. While the cage is being set in place the sleeve is tucked behind one of the iron uprights and so held shut (*b*, Pl. 40, Fig. 1). The celluloid top allows the operator to see into all parts of the cage.

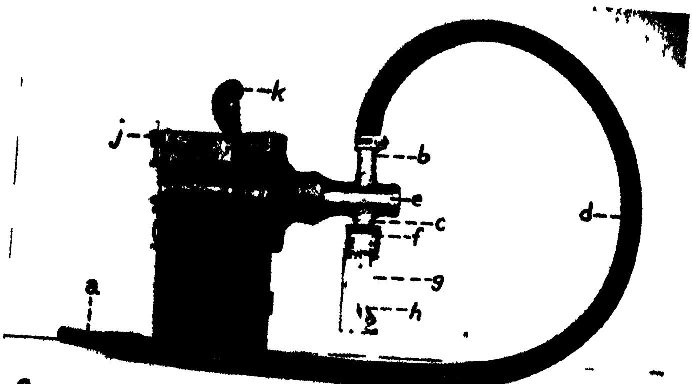
COUNTING METHODS.—If the cage is so placed over the plants that the sun is on the side opposite the sleeve the insects will congregate on this side of the cage. However, if an accurate count is to be made the insects must in some way be removed and, if very numerous, killed. This is done by one of two types of vacuum insect collectors. One is a modified pipette, the suction being provided by the operator's lungs. The other is an electric vacuum collector, the suction being supplied by a small motor-powered blower fan. The former type is used when the insects are few and temperatures are such that they are not very active, as in early spring and late fall. The electric vacuum collector is used during the warmer months when the insects are abundant and active.

THE MODIFIED PIPETTE OR MCGINNIS COLLECTOR.—The suction collector described here is a modification of one first used by G. R. McGinnis[1] in 1923 for the collection of *E. tenellus* from breeding cages and is useful for removing insects from the cage described above when accurate counts are made of moderately small insects.

The apparatus consists of a T tube with rubber tubing attached for the conduction of air and insects (Pl. 40, Fig. 3). At the point *a* is a brass cloth screen of 40 meshes to the inch to prevent the insects from being drawn through the suction tube. The end of the T tube opposite the intake is fitted with a cork, *b*, to accommodate a 3-dram

[1]Temporary field assistant at the time.





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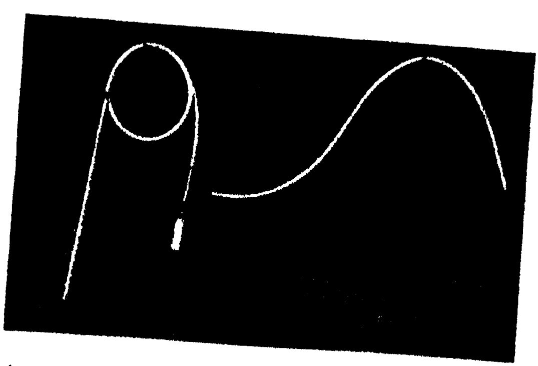

1.—Square foot counting cage; 2—Electric vacuum insect collector; 3—Modified pipette or McGinnis collector

homeopathic vial. If populations are low enough the insects in this vial may be counted alive; if not, they are easily transferred to a small cyanide jar. This collector should always be used with vial down.

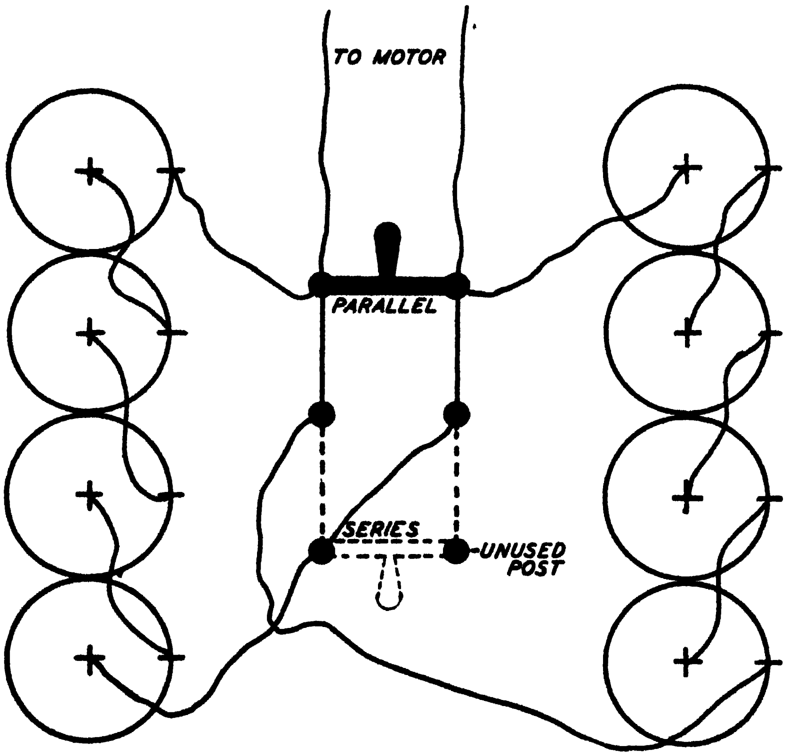

Fig. 70.—Diagram of hook-up for battery box used on electric vacuum collector.

THE ELECTRIC VACUUM COLLECTOR.—This apparatus has proved a most valuable aid in making counts of *E. tenellus* when populations are high. With it from 40 to 50 adults and twice as many nymphs have been removed from the cage in 5 minutes.

The motor and blower fan (painted black, Pl. 40, Fig. 2) were purchased assembled as they appear in the photograph. This assembly is intended for forced circulation in automobile heaters and is handled by dealers in automobile supplies. The nickle-plated apparatus soldered to the blower assembly works on the same principle as the McGinnis collector. The tubing used is thin, nickle-plated brass obtainable at hardware stores. Tubes *a*, *b*, *c*, and the rubber tube *d* are seven-eighths inch in diameter. The rubber tube is 4 feet long.

Passing through the horizontal tube *e* and connecting the ends of the tubes *b* and *c* is a screen tube of 40-mesh brass cloth. The large cork *f* is glued in place on the tube *c*. The container *g* is easily detached to remove or inspect the catch. The insects are killed by cyanide gas generated by granular calcium cyanide placed in the 3-dram vial *h*, which is closed with a piece of muslin.

The battery box *i* is made of ply-wood and will accommodate eight dry cells. Although four dry cells in series will develop the necessary 6 volts to pull the motor it was found that the use of two banks of four batteries each, connected to the motor in parallel, would lengthen the life of the batteries, and when they become too weak to pull the load with this hook-up all eight batteries can be connected in series and considerably more service obtained.

In order to simplify this change of hook-up when the batteries are partially exhausted the box has been so wired (Fig. 70) that by means of a double-throw, double-pole switch on the outside of the box, the hook-up can be changed from the two banks in parallel to eight cells in series.

A small switch, *j* (Pl. 40, Fig. 2), serves to start and stop the motor. A ¼-inch hemp rope and a piece of garden hose, *k*, make an adequate carrying handle.

Scientific Notes

An Unreported Habit of the Seed Corn Maggot, *Hylemyia cilicrura* Rond.—During December, 1931, while investigating an outbreak of the bean aphid, *Aphis rumicis* L., on spinach in the Winter Garden district of Texas, the writer received reports to the effect that the crop is very often seriously damaged by a bud-worm. Upon investigation a dipterous larva was found to be the form involved. Flies reared from larvae collected injuring the crop were determined as *Hylemyia cilicrura* Rond. by Dr. J. M. Aldrich of the U. S. National Museum.

Injury is caused by the larva infesting and damaging the immature unfolding leaves at the apex of the plant above the crown. Owing to this habit of attacking the host plant above ground, which, so far as can be ascertained, has not been reported heretofore, the pest is known locally as the "spinach bud-worm." Although plants injured are not destroyed outright, damaged crops are considered unfit for shipment because of the deformity produced. Plants having a loose spreading terminal growth seem to be less subject to attack than those having a compact terminal growth. According to the information obtained from several growers, the "bud-worm" injures spinach only during periods of rainy weather. Incidentally, under the same weather conditions, mildew, or "blue mold," very often infects and seriously damages the crop. The decay produced by this disease may be an influencing factor in causing this fly to depart from its normal habit of ovipositing in the soil and breeding on subterranean matter.

This same type of damage to spinach has been reported in the Walla Walla district of Washington by Mr. M. C. Lane. He reports, however, that no noticeable disease such as mildew or mold was observed in conjunction with the insect damage, and also that the damage appeared to be more severe in fields where heavy applications of barnyard manure had been made previous to planting.

C. E. SMITH, *Associate Entomologist, Bureau of Entomology, U. S. Department of Agriculture*

A Spray for Insect Control in Empty Grain Bins. Due to the low price offered for grain in 1931 and 1932, larger quantities than usual have been held in storage on farms and in elevators in Illinois. Some of this grain has been held for two or three years. This condition has resulted in a marked increase in stored grain insects in many instances.

A spray of eight per cent miscible oil and three pounds of lye to one hundred gallons of water applied to the empty grain bins has given good results as a clean-up treatment. A miscible oil of the type used for spraying dormant trees for scale is satisfactory for this purpose. Dendrol is the trade name of the oil that was used in these tests.

The spray should be applied until the walls and floor are thoroughly soaked. Enough spray must be applied to thoroughly wet all waste grain, chaff and dust that has not been removed from cracks and corners.

The addition of lye to the miscible oil spray improves the wetting and penetrating properties. This spray solution will enter cracks and wet dust and chaff readily. It is also effective against adult beetles which are difficult to wet and kill except with unemulsified oils.

If the spray is allowed to stand in pools on a painted floor it will soften the paint. The spray does not corrode metal if it is applied so that it dries in three or four hours. The caustic properties of the spray are rapidly neutralized by the CO_2 of the air and organic material such as chaff.

The foundation of the bin and any chaff or waste grain under or near the bin should also be thoroughly wetted. Caution should be used in spraying piles of waste grain containing a bushel or more as the water in the spray may cause the grain to heat.

E. R. MCGOVRAN, *Research Entomologist, Crop Protection Institute, Urbana, Illinois*

A New Strawberry Pest. On February 26, 1932, the writer received a message from a strawberry grower at Long Beach, Miss., advising him that insects were literally destroying his strawberries, particularly the ripe and nearly ripe fruit. The grower stated that fully 90 per cent of his ripe berries had to be thrown out or classed as culls on account of the holes in the fruit. An examination revealed the presence of an abundance of the black cutworm, *Agrotis ypsilon* Rott., some mole crickets, *Scapteriscus aculeatus* R. & H., sowbugs, and a small black tenebrionid beetle, *Crypticus obsoletus* (Say) (determined by E. A. Chapin) beneath nearly every plant. When the plants were disturbed or the soil beneath them

was stirred, the beetles, averaging from 5 to more than a dozen to a plant, would run in all directions. If the plants were handled carefully, the beetles would remain perfectly still beneath clods and loose soil and go unnoticed. The grower was of the opinion that the beetle was doing most of the damage, but the writer could not agree, since he had never before found this insect injuring strawberries.

After the cutworms and mole crickets had been controlled by spreading a poisoned bait among the infested plants, it was found that these beetles either refused to feed on the bait or were unaffected by it, and the injury continued. Further examination of the infested field by the writer, assisted by Mr. G. L. Phillips and the grower, disclosed a number of beetles feeding inside the ripe fruit, especially where care had been taken not to jar the fruit, thus causing the beetles to drop to the ground and conceal themselves beneath clods and elsewhere

This beetle has since been found injuring strawberries in several fields throughout the season, but it was numerous only in the one field at Long Beach, which was near a large dairy barn. Some injury by the beetle was observed in other fields up to May 30. So far as known, this is the first record of injury to strawberries by this beetle.

M. M. HIGH, *Associate Entomologist, U. S. Bureau of Entomology*

Efficiency of Lubricating and Tar Oil Emulsions Against Scurfy Scale (*Chionaspis furfura* Fitch). Experiments conducted in the Hudson Valley in 1932 and 1933 as to the effectiveness of various strengths of lubricating oil emulsions and tar washes in controlling scurfy scale, indicate that both materials may be used efficiently. In 1932 a 4, 5 and 6 per cent lubricating oil emulsion (Diamond paraffin emulsified with Bordeaux mixture) was used, while in 1933 this treatment was used at 3 and 4 per cent, and a tar wash (Arbo) at 2, 4 and 6 per cent strengths. All sprays were applied in the spring while the trees were still dormant. The results obtained are given in the following table:

Treatment	Hatched egg masses	Killed egg masses	Masses killed, per cent
	1932		
6% lubricating oil	117	1,634	93.31
5% lubricating oil	114	680	85.64
4% lubricating oil	91	805	89.84
Check	1,243	19	1.50
	1933		
6% tar wash	29	811	96.55
4% tar wash	252	668	72.60
2% tar wash	133	302	69.43
4% lubricating oil	292	729	71.40
3% lubricating oil	453	407	47.33
Check	976	11	1.11

The above data were obtained after examinations of scales on check trees showed that hatching was complete. In both 1932 and 1933 the scurfy scale had completed hatching by the last of May. The egg masses counted were on branches taken at random from various positions on the trees. The egg masses which had hatched normally were distinguished by the presence of light-colored membranous egg-shells, as contrasted with the dark, shriveled appearance of eggs killed by spray, and by the proximity of numerous young individuals. The number of eggs under

each egg mass varied from 7 to 83 with an average of about 40, and normally 98 per cent of the eggs hatch.

No noticeable injury to the trees resulted from the use of the tar washes. Bud development was delayed and a few buds were killed where the 5 and 6 per cent oil emulsion was used; this condition proved of little consequence, however, since the trees soon assumed a normal appearance.

L. E. AULL, and R. W. DEAN, *Vassar Laboratory of the N. Y. Agricultural Expt. Station*

The Relative Toxicity of Some Fluorine Compounds as Stomach Insecticides. In 1930 the senior author, now at the University of Minnesota, determined roughly the relative toxicity for the silkworm of a number of fluorine compounds prepared by the junior author. The leaf-sandwich method, described by Campbell and Filmer (Trans. IV Internat Cong. Ent. Ithaca, 523–533. 1929) and modified by Campbell (Jour. Econ. Ent. 23: 357–370. 1930) was employed. In Table 1, each result is expressed as a median lethal dosage range within which lies the median lethal dose. The solubilities in water of the compounds tested were determined by the junior author (Indust. Eng. Chem. 20: 1195. 1928; *ibid.* 22: 886–889. 1930). These solubilities are listed in Table 1.

TABLE 1. FLUORINE COMPOUNDS, THEIR SOLUBILITIES IN WATER, AND MEDIAN LETHAL DOSES FOR FOURTH-INSTAR SILKWORMS[1]

Compound	Formula	Solubility at 25° C. Grams per 100 cc.	Median lethal dosage range Mg. per gram
Fluorides:			
Sodium	NaF	4.054	0.11–0.15
Manganese	MnF_2	.186	.20– .40
Lead	PbF_2	.066	.25– .40
Magnesium	MgF_2	.013	>.57
Fluosilicates:			
Sodium	Na_2SiF_6	.762	.10– .13
Potassium	K_2SiF_6	.177	.07– .10
Barium	$BaSiF_6$	.025	.09– .12
Fluoaluminates:			
Sodium	Na_3AlF_6	.061	.05– .07
Potassium	K_3AlF_6	.158	.08– .10
Ammonium	$(NH_4)_3AlF_6$	1.031	.11– .14

[1]For comparative purposes it may be helpful to state here that the median lethal dose of acid lead arsenate is about 0.09 mg. per gm.

The solubility of the fluorine compounds in water was not directly related to toxicity except among the four fluorides. In the first paper mentioned above, Campbell and Filmer published median lethal doses for commercial samples of potassium fluosilicate, barium fluosilicate, and sodium fluoaluminate. The higher degree of purity of the present samples may account partly for their greater toxicity for the silkworm. The present senior author also tested the fluoaluminates of strontium, zinc, barium, magnesim, and calcium. They were less toxic than the fluoaluminates listed in Table 1. Their toxicity decreased in the order named. The results with these compounds are not given in Table 1 because they were of indefinite composition and their solubilities were not determined.

H. H. SHEPARD, *Bureau of Entomology*, and R. H. CARTER, *Bureau of Chemistry and Soils, U. S. Department of Agriculture*

The Effects of Various Commercial Calcium Arsenates on Bean Foliage. Owing to the increased interest in the use of calcium arsenate as a substitute for lead arsenate in order to avoid the problem of lead residue on edible portions of fruits and vegetables, results of three seasons' investigations on the effects of calcium arsenates on bean foliage have been summarized. Since facilities for publishing this report are not available, owing to its length and scope, it has been multigraphed by the Bureau of Entomology.

The report deals with the effects of 19 commercial calcium arsenates on the foliage of green beans in Ohio during 1929, 1930, and 1931. It shows that 5 of the brands were arbitrarily rated as safe, 5 brands were rated intermediate, and 9 brands were rated as unsafe, for use on bean foliage.

The following conclusions were drawn:

Previous experience has indicated—and the conclusions are substantiated in this investigation—that hydrated lime is the most practical corrective for use with commercial calcium arsenate on bean foliage. A combination of sulphur and hydrated lime is an efficient corrective in the proportions of 1–1–4 by weight (calcium arsenate, sulphur, and hydrated lime, respectively).

Bordeaux mixture is an excellent corrective and is more effective than lime, but may itself cause plant injury under certain conditions if used alone.

Copper-lime dusts are good correctives but may cause foliage injury as in the case of Bordeaux mixture if used alone

The rate of evaporation in the air as measured by atmometer spheres appears to be an important index of atmospheric conditions which influence the degree of foliage injury caused by the application of calcium arsenate to bean foliage. Quick drying of the spray tends to mitigate foliage injury.

It is difficult if not impossible in many instances to correlate the effects of humidity and temperature with the degree of foliage injury.

Water-soluble arsenic, as present in most of the brands tested, is not an important index of foliage injury.

No methods of determining by chemical analysis why some brands "burn" and others do not could be devised by careful investigations carried on cooperatively by chemists.

The uniformity of the gross chemical composition and of the toxicity to larvae and adults of the Mexican bean beetle tends to show that from certain standpoints commercial calcium arsenates are well standardized products. On the other hand, the variability of the effects of different brands as regards toxicity to bean foliage is very great.

A few copies of the report are available for investigators who are interested, and may be obtained from the Bureau of Entomology, Washington, D. C, or from the authors at the following addresses: Neale F. Howard, 151 W. 11th Ave., Columbus, Ohio; F. W. Fletcher, State College of Forestry, Syracuse, N. Y.

NEALE F. HOWARD and F. W. FLETCHER, *U. S. Bureau of Entomology*

A Note on the Insecticidal Efficiency of Kerosene Extracts of Derris Alone and in Combination with Kerosene Extracts of Pyrethrum. In connection with some investigations on household sprays of the kerosene base type, extracts of

derris powder were prepared by percolation and tested in comparison with kerosene against house flies according to a method previously described.[1] Derris extracts were also added to pyrethrum extracts to ascertain if they would increase the final toxicity of such sprays.

The kerosene used was of midcontinent origin—41°A.P.I. distillation range 378°F. (192°C.) to 516°F. (269°C.) with 50% over at 454°F. (234°C.). *The derris powder* was finely ground (about 200 mesh) and was found to contain approximately 2.9% rotenone on analysis by the method described by Roark.[2] *Kerosene extracts* of this powder were prepared by first macerating the powder for several hours with kerosene in a glass percolator and then allowing percolation to proceed slowly. Extracts were prepared on the basis of 23.8 gms. of powder to 100 cc. of kerosene (approximately 2 pounds to 1 gallon.). *Pyrethrum extracts* were prepared by the same method, in the proportion of 11.9 gms. of pyrethrum powder (0.26% pyrethrin 1) to 100 cc. of kerosene (approximately 1 pound to 1 gallon.). The *combination of derris extract* with *pyrethrin extract* was prepared by adding 16.6 cc. of the derris extract prepared as above to 83.3 cc. of the pyrethrum extract. This was tested in comparison with another sample of the same pyrethrum extract which was diluted with 16.6 cc. of kerosene to 83.3 cc. of the extract.

The results of the insecticidal tests are shown in the table:

Series	Test solution	No. of tests	No. of flies	Average 50 per cent paralytic time in seconds	Mortality after 24 hours per cent
1	Kerosene....................	2	94	405	18
	Kerosene extract of derris.....	2	110	332	68
2	Extract of pyrethrum.........	4	197	197	46
	Extract of pyrethrum plus derris extract.............	4	198	190	59

It was clear that kerosene extracts of derris are much more toxic than kerosene alone. Furthermore it appeared that the addition of small amounts of derris extract to pyrethrum extract gives a significant increase in toxicity. Whether the toxicity of the kerosene extract of derris is due to rotenone is a question. Certainly rotenone was present. Jones and Smith[3] report that the solubility of rotenone in kerosene is less than one-tenth of 1% at 20°C. Possibly extractives of derris other than rotenone contributes to the toxicity of the kerosene extract. It is apparent that derris contains some kerosene soluble compounds which add considerably to the toxicity of the kerosene toward house flies.

It might be of interest to mention that kerosene extract of Quassia chips and hellebore (both at the rate of 11.9 gms. per 100 cc.) were tested but they did not appear to add very significantly to the toxicity of kerosene.

This work was part of a Crop Protection Institute Fellowship supported by the Deep Rock Oil Corporation. The author is now with the U. S. Bureau of Entomology, Washington, D. C.

HENRY H. RICHARDSON, *Iowa State College, Ames, Iowa*

[1]Richardson, H. H. Jour. Econ. Ent. 24 (1): 97–105. (1931).
[2]Roark, R. C. Soap 7, No. 3, 97–101. (1931).
[3]Jour. Am. Chem. Soc. 52, 2445–52. (1930).

The Occurrence of *Bregmatothrips iridis* Watson in the United States. While investigating the gladiolus thrips, *Taeniothrips gladioli* M. & S., the author on October 26, 1931, collected a few dark brown wingless adult thrips in the leaf axils of the common torchlily, *Kniphofia uvaria*, and a large number on Japanese iris plants at a nursery in Hamburg, N. Y., which were identified by Harold Morrison, U. S. Bureau of Entomology as *Bregmatothrips iridis* Watson. This collection apparently represents the first record of the insect's establishment in the United States. Although this thrips has been intercepted a number of times since 1923 (Watson, J. R. Entomologists' Monthly Magazine 60: 253–254, 1924) on iris imported from Holland, England, and France, it has not been reported as having become established in America.

During the past season other infestations of this thrips on iris have been found by members of the Bureau of Plant Quarantine, or on material which was sent to the Bureau of Entomology, from several places in New York and one in Maryland. An interception in 1932 by Norman Perrine on imported bulbous iris of a single winged thrips was identified as this species by Professor Watson, who commented on the importance of the fact that this thrips sometimes produces winged individuals, its ability to become disseminated being thereby increased.

Although the thrips has been found most frequently on various types of iris, it has been taken on the common torchlily and so it may not be restricted in its host range. The insect may be rather widespread in the United States on iris plantings because these plants have been imported for many years prior to the first discovery of the insect.

The iris plants at Hamburg were again examined on April 18, 1932, and only adult females were present upon the young shoots beneath the sheaths of dead leaves of the plants. No young were present and, since egg laying started soon after the females were placed in a warm temperature, it is evident that the winter is passed as fertilized females. The infestation was again examined in August, 1932, and the thrips were found only on the iris. The thrips, including the milky white larvae and pupae, and the dark colored, wingless males and females, were abundant in the leaf axils.

The foliage of infested plants was rather severely stunted. The areas of leaf tissue which had been fed upon while in the sheaths and then grew out by leaf elongation appeared brownish or rusty colored. The few late flowers were not injured and the grower stated that he observed no flower injury during the whole season. The discolored and stunted foliage was noted by recent correspondents desiring information on the cause of the injury to their plants.

With reference to control it appears that rather drastic measures would be required to clean up infested plants because of the secluded situations in which the insect occurs. Spraying or dusting would appear to offer temporary relief rather than elimination. The latter may be possible by digging the plants in the late summer, when they are usually dug for division and replanting, and immersing them in hot water for from 15 to 20 minutes at a temperature of 120°F.—a treatment which has been provisionally adopted for imported iris by the Bureau of Plant Quarantine pending adequate research on the control of this species.

FLOYD F. SMITH, *Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology*

The Influence of Insects in the Souring of Figs. In the summer of 1928 while engaged in investigations on figs in connection with the operation of the Federal food and drug act, a series of experiments was made to throw light on the possible influence of insects in the souring of figs. This souring in figs is caused by various yeasts and bacteria and it was felt that insects entering the figs probably acted as carriers of the microorganisms. For the experiment, a certain tree in a fig orchard a few miles southeast of Fresno, Calif., was generously set aside for our use by the owner. The plan was to prevent insects from entering a portion of the figs on the tree and to compare these after maturing and drying with other figs from the same tree which had not been thus protected.

At the outset, three methods of protection suggested themselves. These were: (a) to smear over the ostiole or "eye" of the fig a layer of automobile grease, (b) to use "tree tanglefoot" for this purpose, and (c) to enclose the figs in small cloth bags. After the first test it was found that the automobile grease killed the tissues it came in contact with and hence invited decay. Therefore, its further use was abandoned. The tanglefoot did not seem to affect the tissues adversely.

Each set after preparation was allowed to remain on the tree until the figs ripened and dropped on the ground in the usual fashion. Three successive sets were started about a week apart between August 18 and early September. At each time of visit to the orchard those figs that had dropped since the last visit were collected and tested.

In choosing the figs for the experiment, note was made of the stage of development as indicated by the condition of the scales around the "eye", since as the figs approach maturity the scales draw apart, making the entrance of the insects an increasingly easier matter. In "stage 1" were classed those figs in which the scales appeared closely interlocking, while in "stage 2" were classed those figs wherein the scales were beginning to open appreciably. Observations of many individual figs previous and subsequent to this experiment, revealed the fact that the dried fruit beetle and the vinegar fly sometimes crowd their way into figs that would at first be regarded as too tightly closed. This may help to explain the small number of sours that were found on testing the figs in the "stage 1" series.

Samples of the naturally handled, unprotected fruit from the same tree were gathered periodically and tested according to the methods used for figs in the Federal Food and Drug Adminstration (1). During the experiment six sets were collected and tests gave the following average:

Insect infested	37.2%
Moldy	2.0
Sour	16.0
Bird-pecked and dirty	3.4
Passable	41.4

According to the technique of the method of testing, the above figures fail to reflect perfectly the full extent of souring, since no fig is counted in more than one class, and if it is insect-infested as well as sour, it is classed only as the former. As a matter of fact, a very large proportion of those classed as insect-infested were also sour.

Examination of the protected figs showed the following:

	State of development			
	Stage 1		Stage 2	
	Scales closed		Scales opening	
	No.	Per cent	No.	Per cent
Figs with sour odor	2	2.1	3	10.0
Figs with traces of yeasts or bacteria	4	4.2	3	10.0
Figs with no evidence of souring	89	93.7	24	80.0

There was no significant difference in souring between those protected by the cloth bag and those treated with tanglefoot.

A comparison of the results obtained in the unprotected series with those obtained in the protected series, especially those of "stage 1," reveals a very marked difference in that in the latter group only about 2 per cent showed souring to such a degree as to be organoleptically detected.

Although the extent of the experiment was too limited to warrant drawing final conclusions, the results obtained certainly appear sigificant.

In conclusion the writer wishes to acknowledge the cooperation of members of the Stored Products Insect Investigation Laboratory of the United States Bureau of Entomology, located at Fresno, Calif., in conducting the experiment

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JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1933

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings: 1933-34 Boston; 1934-35 Pittsburgh; Summer meetings: 1933 Chicago. 1934 San Francisco

Economic or applied entomology deals primarily with insect control. This work is playing an increasingly important part in the economic life not only of this Nation but in all countries throughout the world. The National and international character of this activity is strikingly evident in a recent book entitled: "Fighting the Insects, The Story of an Entomologist." It is really an autobiography of one who held for many years with great credit the entomological leadership of the world. The story of his early years agrees in large measure with similar accounts of other noted men of science. Entomologists will find in this volume inspiration, since it details briefly and interestingly many of the numerous contacts the author was able to establish with leaders in scientific thought, both in this country and abroad. It records a gradual and healthy increase in a general realization of the importance of economic entomology and the acceptance of the entomologist as an equal by leading students in other branches of learning. The book calls attention, by implication at least, to the importance of numerous personal contacts with investigators in other sciences and with men of affairs, both valuable agents in molding public opinion. This is the story of a man who visualized clearly the human relations of his science and by virtue of his position and connections was able to bring it most effectively to the attention of the entire world. The title: "Fighting the Insects" though usually interpreted to mean something very different, namely, actual

work in the field, is entirely justified by the contents of the work, since it deals with a very important phase of insect control. The book contains much of human interest in relation to a man who has enjoyed exceptional opportunities in his chosen work. There were tremendous advances made during his period of active service. There are possibly even greater advances to be made in the not distant future. The volume illustrates in a striking way the value of well directed, intense research or specialization, and at the same time, emphasizes the importance of the broader outlook which reaches beyond State and National boundaries. There is need of more such men.

Obituary

CLARENCE RITCHIE PHIPPS

1895—1933

CLARENCE RITCHIE PHIPPS died Wednesday morning, June twenty-first. He had been occupied with his entomological work all day Monday (June nineteenth) apparently in his usual health but he became acutely ill that night. Tuesday an operation was deemed imperative and his wife, who was visiting her parents in Syracuse, New York, was informed of his serious condition. Mrs. Phipps arrived by chartered airplane, and in appreciation of her haste her husband's smiling welcome was, "Esther, you made good time." His sudden exit from the various activities in which he had so keen an interest took place a few hours later. He is survived by his wife, Esther Sears Phipps, his son Richard, and his mother, Mrs. Phipps of Quincy, Massachusetts.

In preparation for his professional work, he received his degree of B.S. from the Massachusetts Agricultural College in 1919, M.S. from Iowa State College in 1927, and Ph.D. from Cornell University in 1930. From 1919–21 he served as Assistant Entomologist at the New York Experiment Station, Geneva, New York. From 1922–25 he held the position of Entomologist at the State Fruit Experiment Station, Missouri. Since July 1925 he has been in charge of the Purnell Projects in the Department of Entomology at the Maine Agricultural Experiment Station. At all three institutions with which he was connected, he was engaged in economic work with fruit insects.

Fruit growers in Maine who placed their insect problem before Doctor Phipps realized his earnest efforts in their behalf and repeatedly ex-

Plate 41

Clarence Ritchie Phipps

pressed their appreciation of his help. His recent publications on blueberry insects and the apple fruit fly have been received with praise by his entomological colleagues.

Those associated with him in his professional work found Doctor Phipps patiently persistent in his endeavors, conservative in his judgment, pleasant in his personal contacts, ready to accept pertinent advice, generous in his evaluation of the work of others, earnestly and progressively ambitious to improve the caliber of his research in each new undertaking. He had unusual ability in the organization of essential details in planning his projects and in recording the results of his observations. To quote from the June 28, 1933, issue of *The Station News*, of Geneva, New York: "That he would attain still further heights in his chosen field of work was the expectation of all who knew him."

Doctor Phipps, by nature quiet, sincere, gracious, had won the respect and affection of a wide circle of friends. One of these, Mr. Arthur Stevens, says of him:

"The loss to Entomology in the passing of Doctor Phipps is not greater than the loss to the community in which he made his home. Outside of his work his first thought was to his family. As a husband he had the two greatest contributions to happiness—sympathy and understanding. His intelligent devotion to his son was a type that inspires and encourages useful citizens for the next generation.

"Doctor Phipps had a variety of hobbies and interests. Perhaps the foremost of these was Contract Bridge. He was an excellent player and a sporting loser. Baseball claimed some of his enthusiasm, especially the fortunes of the Boston Braves. He was more than casually interested in all outdoor sports and handled most of them in a capable manner. His tennis was better than the average. He was an ardent fisherman. He had recently joined the Penobscott Valley Country Club and was looking forward to improving his golf.

"Perhaps the greatest asset in Doctor Phipps' character was his consideration for other people. He was unfailingly thoughtful of the comfort of others, even to his own discomfort. His pleasure seemed to be the pleasure of others and his will the convenience of his associates. His sudden passing came as a shock to his friends who will hold in memory a realization of so true a man and a sadness in the loss of so fine a friend."

EDITH M. PATCH.

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Current Notes

The pale western cutworm situation in Alberta, Canada, is somewhat more serious than was expected, owing to peculiar weather conditions of the season.

Mr. A. G. Dustan and other members of the Entomological branch at Ottawa have noted with interest that there is no evidence indicating that the gladiolus thrips winters outside in that latitude.

Glenn M. Kohls and Carl L. Larson, Assisant Entomologists, returned to the Laboratory at Hamilton, Montana, after two months in the field on a tick survey through several of the states of the southwest and Pacific Coast.

The white grub outbreak expected in eastern Ontario, Canada, is proving to be even worse than anticipated. Extensive damage is being caused on a very large acreage entailing a threatened shortage of winter fodder on many farms.

Mr. Arthur Kellsall, Entomological branch, reports that insectary feeding tests being carried on by Mr. S. H. Payne are showing that the new process white arsenic, used alone or combined with fungicides, is considerably more toxic per unit of arsenic than lead arsenate.

The grasshopper outbreaks in Manitoba and Saskatchewan proved to be extremely destructive and in the former locality was one of the worst known in the history of the province. The areas of outbreak conformed excellently to the forecast map issued in the early season.

Mr. W. A Ross, Entomological branch, reports that a 20 per cent lubricating oil spray applied to pear trees for the eighth consecutive year caused no serious injury apart from the usual marked retardation in the development of leaf buds. The trees sprayed with 10 per cent appear to be normal.

The gladiolus thrips, *Taeniothrips gladioli* M. & S., was first found infesting gladiolus in South Carolina at Clemson College on June 3rd, 1933. The specimens were found on plants which grew from infested corms which were imported from Rose Hill, N. Y. in November, 1932. The corms were fumigated before being planted, but the treatment was evidently insufficient to kill all individuals present.

Among interceptions of diseased nursery stock in Canada, one of *Taeniothrips gladioli* is of special interest. This insect was found in a shipment of 125 gladioli bulbs from Australia. The insect was identified by M. B. Steinweden of San Francisco. In June another shipment of gladiolus consigned to Winnipeg from New Zealand was found infested with thrips, but the species has not yet been determined.

The Pan Pacific Science Congress was held at Vancouver, B. C., June 5–14. Entomologists present from outside of Canada included Dr. Tillyard of Australia; Dr. Swezey from Honolulu; Dr. Harry Smith from California; Dr. Parker and Dr. Cooley from Montana; Dr. Mote from Oregon and Dr. Kincaid from Washington University. The Canadian members included many of the officers of the Branch in British Columbia, three from Ottawa and several from the University of British Columbia.

Mr. Norman Criddle, entomological branch, died at Brandon, Manitoba, May 4th. He died as the result of an operation late in April which was necessary be-

cause of poor health during recent years. He had been in charge of the Treesbank laboratory for a period of nineteen years and was a well known worker in the field of entomology. On March 31st, the Manitoba Agricultural College granted him an honorary diploma, the highest honor in their power to bestow, in recognition of his accomplishments on behalf of agriculture.

During the 20th annual meeting of the New Jersey Mosquito Extermination Association held at Atlantic City, N. J., April 20 and 21, it was reported that since the year 1900, there has been spent in New Jersey over six million dollars for mosquito control. The assessment value of property in the state during the same period rose from 64 million dollars to 736 million dollars in 1930. Much of this property is situated in sea-shore locations, and previous to mosquito control, was comparatively useless.

Members of the Rocky Mountain spotted fever Laboratory, Hamilton, Montana, who attended the Vancouver meetings of the Fifth Pan Pacific Science Congress, were Dr. R. R. Parker, Officer in Charge, and Mr. R. A. Cooley. Dr. Parker read a paper regarding recent advances in the study of tick-borne diseases in the western United States and Professor Cooley summarized present information on tick parasites and attempts to colonize *Ixodiphagus caucureti* in certain localities in the West. In honor of his long service to economic entomology, Professor Cooley was inducted for the day as temporary chairman of the biological section.

The last meeting of the Entomological Club of Southern California for the year 1932–1933 was held on June 2, at the University of California at Los Angeles, with an attendance of 91 members. The following newly-elected officers were installed: President, A. F. Swain, Pacific R. & H. Chemical Corporation, El Monte: Vice-President, S. E. Flanders, University of California Citrus Experiment Station, Riverside; Secretary and Treasurer, H. C. Lewis, California Fruit Growers' Exchange, Los Angeles. The retiring officers were: President, C. I. Bliss, U. S. Bureau of Entomology, Whittier; D. W. Tubbs, Agricultural Commissioner of Orange County, Santa Ana; Secretary and Treasurer, A. M. Boyce, University of California Citrus Experiment Station, Riverside.

Joint Meetings of Section F. with Affiliated Entomological Societies and Joint Meeting of American Association of Economic Entomologists and Entomological Society of America at Chicago, Ill., June 22, 23, 1933. A joint meeting of Section F. of A. A. A. S. with the affiliated entomological societies was convened at the James Simpson Theater, Field Museum, on June 22 at 10 A. M., with about 150 in attendance. The president of the American Association of Economic Entomologists, Dr. W. E. Hinds, presided during the opening address which was given by Dr. R. J. Tillyard of Canberra, Australia. Dr. Tillyard presented an interesting and well illustrated discussion of various theories of "The Evolution of Insects," closing with a statement of his own conclusions which have been based upon long study in this field.

Dr. A. J. Carlson presided during the second address of the joint meeting which was given by Dr. A. V. Hill, of University College, London. Dr. Hill spoke upon "Wave Transmission as the basis of nerve activity."

Entomologists Dinner at Chicago. At the joint banquet of the two entomological societies held in Chicago the evening of June 23, Dr. C. H. Richardson, Vice-

President of the Entomological Society of America acted as toastmaster. After opening the gathering, the meeting was turned over to President W. E. Hinds of the American Association of Economic Entomologists. He presented to Past President Flint a diploma to acknowledge his effective leadership of the Association during the past year. Very interesting talks were given by Dr. E. F. Phillips on "Entomology in Soviet Russia—with particular reference to Beekeeping," and by Mrs. Phillips on "Certain Aspects of Home Economics in the Land of the Soviets."

President Hinds then announced that on May 14 he had appointed a special committee, consisting of Messrs. Britton, Cory, Felt, Houser and Phillips (chairman), to do whatever was possible to preserve the integrity of the entomological investigations and services of the federal government and of the state investigations supported by federal funds. A preliminary report of this committee was then read by the chairman in which the work of the committee to date was briefly outlined. The committee met in Washington May 19 and remained there for three days, during which time a considerable number of interviews were held. Since at that time definite annoucements had not been made regarding the proposed reorganization of the federal services or regarding the proposed reductions, the committee confined its efforts to the making of certain specific recommendations which it hoped might be followed in the changes which are ahead. Insistence was placed on the importance of retaining the entomological research as a single administrative unit, since it has been proposed to split the work among a number of distinct bureaus. It was also urged that the foreign quarantine be retained with as little reduction as possible, and that funds for state investigations be continued, since many of them are long time projects, for which much valuable data would be lost if they were suddenly curtailed.

Following the reading of this report, the meeting was turned back to Vice-President Richardson, after which it was moved and duly passed that the same committee be authorized hereafter to act also on behalf of the Entomological Society of America, the expenses to be met jointly by the two organizations.

Horticultural Inspection Notes

A conference to consider the suppression and prevention of spread of the potato wart disease is scheduled to be held at Hazelton, Pa., on July 28.

Under BPQ-352, the Federal Bureau of Plant Quarantine has issued a definition of the term "commercially-packed shipments of apples," as used in the Japanese beetle quarantine regulations.

According to the Florists' Review, Phil S Haner, of Taylorville, Ill., superintendent of the division of plant industry of the Illinois state department of agriculture and an honorary member of the Illinois State Nurserymen's Association, died July 17 at Springfield, Ill., following an operation.

J. D. Winter who was in the nursery inspection service of the state department of agriculture, severed his connection with that work July 1. Mr. Winter, according to the Florists' Review, is now Secretary-treasurer of a new organization, the

Minnesota Fruit Growers' Association. Growers from all over the state are eligible for membership.

Mr. Ralph M. Seeley, formerly connected with the gipsy moth project of the Bureau of Entomology, United States Department of Agriculture, has been appointed horticultural inspector in the New York State Department of Agriculture and Markets, with headquarters at Binghamton.

The Office of State Entomologist of Wyoming has now been moved to Powell. It continues as a branch of the State Department of Agriculture with headquarters at Cheyenne, but letters for the attention of Mr. C. L. Corkins, State Entomologist, should be addressed to Powell to receive prompt attention.

Certain varieties of Castanea are now admissible into Illinois under certain safeguards and "in cases where it is desirable to import [them] because of their resistance to the Chestnut bark disease and superior quality of the fruit produced." The proclamation is dated April 29, 1933, and modifies the embargo formerly in effect.

The alfalfa weevil quarantine of the State of Michigan was revised on May 4 as a result of surveys made and data collected "which show that infestation exists in five new counties in California and two new counties in Nevada." The newly quarantined counties are Alameda, Contra Costa, Mono, San Joaquin, Santa Clara, and Stanislaus in California, and Eureka and Landers in Nevada.

New reports on the Dutch elm disease by the Federal Bureau of Plant Industry show that the disease has been discovered on at least nine American elm trees at Maplewood, South Orange and East Orange, N. J. One additional infected elm has also been located at Cleveland, Ohio. No nursery has been found infected nor has any connection yet been established between the various diseased trees and any nursery.

Under a recent reorganization of the State Department of Agriculture of Michigan, Samuel T. Metzger was named Commissioner of Agriculture, and C. D. Doane, Chief Apiary Inspector. Mr. E. C. Mandenberg continues in charge of nursery and orchard inspection. Inspectors working under his direction include C. A. Boyer, A. H. Beyer, H. Kiebler, L. Small, H. Tichnor, J. Garver, W. N. Banfield, H. N. Blackmer, Sidney Davis, Clifford Rowe, Francis Meiers, Robert Audrain, and Kenneth Clark

Recent revisions of the Wisconsin and Missouri regulations relating to the European corn borer remove from the list of restricted articles celery, oat and rye straw, cosmos, zinnia, and hollyhock; place no restrictions on floral plants and vegetables entering from Michigan, Ohio, and Indiana; and provide for the acceptance without restriction of green corn during a portion of the year and of chrysanthemums, asters, and dahlias without old stems during four months of the year. The Wisconsin order became effective on June 16 and the Missouri order on July 10.

Mr. L. M. Gates, Nursery and Apiary Inspector of the Nebraska State Department of Agriculture, reports that the last legislature reduced to $10,000 an appropriation which had previously amounted to $25,000 per biennium for the control

of the European corn borer or other highly dangerous insect pests. This fund has heretofore been employed primarily for grasshopper control and it is stated that $7,000 of the biennial appropriation has already been spent for grasshopper poison bait this season. The outbreak is so severe that according to Mr. Gates much more is needed.

Based upon assurance from the Oregon officials that no cherry fruit fly infestation is to be found in the counties of Union, Baker, and Wallowa in that State, the California State Department of Agriculture on June 8, modified its quarantine relating to these pests by eliminating these counties from the areas under regulation. The modification is designated "Quarantine Proclamation No. 8," the first "Proclamation," according to the Department which it has issued. The term "Quarantine Proclamation," is to be used when areas in other States are involved, but "Quarantine Regulations" when areas in California are involved.

Shipping restrictions with reference to the phony peach disease have been passed recently by the States of Mississippi, Arkansas, and Delaware, which include the following requirements as a condition of entry of the susceptible plants: (1) Disease-free plantings and disease-free environs within a mile thereof; (2) borer-free stock as determined by hand inspection after digging. In the case of Delaware, stock which meets either condition (1) or (2) is acceptable. As a further condition of certification, the State of Mississippi also requires that the stock be produced in a disease-free county.

Supplementary administrative instructions relating to narcissus treatment and pest suppresson have been issued by the Federal Bureau of Plant Quarantine as circular BPQ-353. The new circular authorizes the use of the vapor heat treatment for bulb flies in lieu of the hot water treatment, if desired. It also changes the presoaking requirement by reducing the length of time dry bulbs are required to remain in cold water from 12 hours to 2 hours. A number of interpretations and slight modifications of the administrative instructions concerning narcissus inspection issued last year are included.

The Ohio State Department of Agriculture recently issued a regulation relating to the two-generation strain of the European corn borer. The order, which became effective on July 7 applies only to the New England States, New York, New Jersey, Pennsylvania, and Virginia, and provides for acceptance of the restricted articles when manufactured or processed, and of floral and vegetable plants and products when certified. It places no restrictions at any time of the year on celery, oat and rye straw, dahlia tubers or gladiolus corms without stems, or cosmos, zinnia, or hollyhock. From January 1 to June 1 each year, green corn, chrysanthemums, asters, dahlias, and cut gladiolus without old stems, may be admitted without restriction.

Active steps are being taken by the Bureau of Plant Industry of the New York State Department of Agriculture and Markets to bring under control an infestation of the European pine shoot moth in the nurseries of southeastern New York State. For this purpose a control measure worked out by Dr. R. D. Glasgow, State Entomologist, is being employed. The method consists of spraying with any one of a number of formulae. It is stated in the circular of instructions issued by Doctor Glasgow and Mr. B. D. Van Buren that the most successful of these formulae

consists of 1½ pints of Cube extract (containing 5% Rotenone oil), and 2 gallons of miscible pine oil in 100 gallons of water. The nurserymen are instructed to spray thoroughly between June 25 and July 4, directing the spray branch by branch, downward and inward, so that it may penetrate the needle clusters from the tip toward the base. Two applications, one near the beginning and one near the end of the period named, are advised. It is stated that this treatment has given good results even in severe infestations.

Mr. L. A. Strong, Chief of the Bureau of Plant Quarantine, United States Department of Agriculture, addressed the American Association of Nurserymen at Chicago on July 20, on the subject "The Past, Present and Future of Quarantine 37." Mr. Strong forecast serious consideration of the modification and liberalization of Plant Quarantine No. 37. Among the fundamentals which he stated should be continued were restrictions on the introduction of soil, a limitation on the age and size of plants to keep them within the Department's ability to make competent inspection, and the continued exclusion of classes of plants that are likely to bring in injurious pests from specific localities. It was stated that greater confidence can now be placed in the efficacy of inspection of plant material at the time of arrival than was possible some years ago. Mr. Strong pointed out the objections to the Federal Department attempting to limit the number of plants to be imported on the basis of the availability of the varieties concerned and stated that he questioned the need for any requirement that imported plants be kept in detention for any certain period of time.

The fifteenth annual conference of the Western Plant Quarantine Board was held at Salt Lake City, Utah, June 12 to 14, 1933. In addition to representatives of many of the western States, there were present Mr. William C. Wood, Chief of the Division of Classification of the United States Post Office Department; Sr. E. Coppel Rivas, of the Agricultural Defense Office of the Republic of Mexico; and Mr. W. H. Lyne of British Columbia. The Board passed resolutions relating to the recognition of State plant quarantines by the Post Office Department; recognition and acceptance of Federal origin inspection and certification as a basis for admitting commodities which might otherwise be embargoed under State plant quarantines; the method of enforcement of the Lacey Act relating to the entry of injurious mammals and birds from foreign countries, and the importance of preventing the interstate shipment of weed seeds. The Board discussed but took no action with respect to the certification of honey in interstate commerce; the spread of the black walnut canker disease; the elimination of the European earwig in the soil about the roots of balled nursery stock; the Colorado potato beetle situation; the outbreak of the strawberry-iris worm; the problem of cooperative border stations; protection against the spread of the potato tuber moth, and the maintenance of identity of fruit and vegetable shipments by means of sealing the containers. The Republic of Mexico was elected to full membership in the Board. W. H. Wicks of Idaho was elected Chairman for the ensuing year; D. C. George of Arizona, Vice-Chairman, and A. C. Fleury of California, Secretary-Treasurer. George M. List of Colorado was elected as representative to the National Plant Board, to serve with A. C. Fleury whose term had not yet expired.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Vol. 26 OCTOBER, 1933 No. 5

Proceedings of the Eighth Annual Meeting of the Cotton States Branch American Association of Economic Entomologists

The eighth annual meeting of the Cotton States Branch was held at New Orleans, Louisiana, on February 2 and 3, 1933. It proved to be one of the best meetings of the Branch and was well attended considering the fact that practically all attendants had to make the trip at personal expense. Two sessions were required for the presentation of the rather long program which dealt with insects attacking cotton, peaches, sugar cane, and other crops grown in the southern region. Considerable informal discussion followed the presentation of the twenty-two papers which were classified as follows:

Insects Injurious to Cotton	10	Insects Injurious to Roses	1
Insects Injurious to Peaches	3	Insects Injurious to Truck Crops	1
Insects Injurious to Sugarcane	3	Miscellaneous Injurious Insects	1
Insects Injurious to Citrus	1	Bees	1
Insects Injurious to Corn	1		

The meeting was attended by the President of the American Association of Economic Entomologists for 1933, Dr. W. E. Hinds, of Baton Rouge, La. In response to the introduction given by Dr. J. W. Folsom, president of the Cotton States Entomologists, and invitation for remarks, Dr. Hinds expressed his appreciation of the honor of representing the parent association at this gathering. He described the meetings of the Entomological Society of Paris, celebrating its 100th anniversary, and the sessions of the Fifth International Congress of Entomology held in Paris July 16–23, 1932, to both of which Dr. Hinds was one of the delegates from the American Association of Economic Entomologists. The Anniversary meeting of the Entomological Society of Paris, which is the oldest entomological society in the world, was honored by the attendance of the President of France with members of his official staff. After welcoming addresses and responses and the address of the president of the Entomological Society, the foreign delegates and representatives

were introduced individually. Most of these delegates appeared in academic dress or in the regalia of the societies which they represented officially. Many of them presented elaborately inscribed or bound expressions of felicitation which were presented to the Entomological Society of Paris for their Archives. A very hearty welcome was given to the representatives from Germany and Austria, as well as those from all other countries. The meeting was characterized by an unusual degree of dignity and grace, with the spirit of friendship and cooperative good will throughout.

The meeting of the International Congress of Entomology consisted of general sessions in the forenoon with sectional group meetings in the afternoon. Most of the papers were presented in French or German and but few were given in English. In only a few cases was an abstract in English given of the outstanding papers presented The French committee had arranged for many features of entertainment, including banquets and sight-seeing trips to Versailles and Fontainebleau. Following the close of the meeting, many of the American delegates visited southern France, through the Pyrenees section and paid a special visit to the home of J. H. Fabre at Serignan, where they were shown through the home and garden by the son who now lives there. A visit was also made to the cemetery where the body of Fabre now lies.

In Italy, Dr. Hinds took advantage of the opportunity to visit Professor Silvestri at Portici, a short distance from Naples. Professor Silvestri speaks several languages fluently, including English, and has visited several times in the United States. It is expected that he will be one of the outstanding foreign entomologists invited by the Chicago Century of Progress Exposition to visit the United States during the coming summer and we look forward to his presence and leadership in sessions of the Association of Economic Entomologists which will be held in Chicago June 20–23, probably.

An invitation was also extended to the Cotton States Entomologists members to attend the summer session of the Economic Entomologists at Chicago in connection with the Chicago Century of Progress Exposition.

The dinner for entomologists and their friends, which was held in a famous restaurant in the French quarter of New Orleans on the night of February 2, proved to be a brilliant occasion. The meeting closed with a tour to places of interest to entomologists in New Orleans. This included a visit to the well-equipped laboratories maintained by the Bureau of Entomology for the investigation of fruit, shade tree and sugarcane insects.

PART I. BUSINESS PROCEEDINGS

The meeting was called to order by Chairman J. W. Folsom at 2:00 P. M., on February 2 in the Roosevelt Hotel at New Orleans, Louisiana. The following were present:

W. E. Anderson, Baton Rouge, La.
F. F. Bondy, Florence, S. C.
M. Brunson, Picayune, Miss.
E. K. Bynum, Houma, La.
T. F. Catchings, New Orleans, La.
K. L. Cockerham, Biloxi, Miss.
A. W. Cressman, New Orleans, La.
E. C. Davis, Baton Rouge, La.
O. T. Deen, Biloxi, Miss.
J. M. Del Curto, Austin, Texas.
W. A. Douglas, Crawley, La.
L. L. English, Spring Hill, Ala.
Alfred Fenton, Houston, Texas.
R. K. Fletcher, College Station, Texas.
J. W. Folsom, Tallulah, La.
J. C. Gaines, College Station, Texas.
J. C. Goodwin, Gainesville, Fla.
W. E. Haley, New Orleans, La.
W. E. Hinds, Baton Rouge, La.
W. B. Hollingsworth, Picayune, Miss.
T. E. Holloway, New Orleans, La.
C. O. Hopkins, Baton Rouge, La.
J. W. Ingram, Houma, La.
H. A. Jaynes, Houma, La.
M. D. Leonard, Orlando, Fla.
B. P. Livingston, Montgomery, Ala.
Clay Lyle, State College, Miss.
J. H. Montgomery, Gainesville, Fla.
C. F. Sarle, Washington, D. C.
C. E. Smith, Baton Rouge, La.
O. I. Snapp, Fort Valley, Ga.
C. L. Stracener, Baton Rouge, La.
F. L. Thomas, College Station, Texas.
G. F. Turnipseed, Spring Hill, Ala.
Fred Wright, Bay St. Louis, Miss.
M. J. Yeomans, Atlanta, Ga.

The report of the Secretary-Treasurer was then read and approved subject to the audit of the auditing committee.

Report of the Treasurer

Balance on hand February 4, 1932		$160.12
Refund from parent association for expenses for the year ending Feb. 4, 1932		32.63
1929 annual dues from 1 member		1.00
1930 annual dues from 4 members		4.00
1931 annual dues from 5 members		5.00
1932 annual dues from 13 members		13.00
1933 annual dues from 2 members		2.00
Paid Out:		
Stamped envelopes	$ 20.63	
Printing announcements and programs	6.50	
Exchange fee on check	.25	
U. S. tax on 5 checks	.10	
	$ 27.48	$217.75
Balance on hand Feb. 2, 1933	$190.27	

Report of the Secretary

The number of members in the Cotton States Branch on December 31, 1932, was 234. There was a net decrease of only 2 members during the year, after dropping those who had moved out of the Branch territory or were dropped by the parent Association for non-payment of dues. This shows that the Branch membership is being well maintained in spite of present conditions. The membership has grown from 158 to 234 in the last six years or a net increase of 76 members, after dropping those who moved out of the Branch territory during that period or had not kept up their dues in the parent Association. Therefore, the number of new members added

to the Branch roll during the last six years was greater than the number represented by the net increase in the Branch membership.

The number of members by states at the close of 1932 was as follows: Texas 54; Louisiana 34; Mississippi 34; Florida 25; Georgia 20; North Carolina 17; Tennessee 17; South Carolina 11; Alabama 10; Arkansas 7; Oklahoma 5. The following states showed net increases during the year: Texas 3; Louisiana 1; South Carolina 1; Oklahoma 1. The following states showed net decreases during the year: Mississippi 3; North Carolina 2; Florida 1; Arkansas 1; Tennessee 1. There was no net change in the number of members in Alabama and Georgia.

There are now 506 entomological workers in the 11 Cotton States who are not members of the American Association of Economic Entomologists, and members are urged to assist in our efforts to strengthen the Branch by increasing the membership.

The Secretary sent to each member of the Branch an invitation to participate in the regular annual meeting in New Orleans, La., on February 2 and 3, 1933. The program for that meeting was mailed to each member on January 23.

Complying with the action taken at the last annual meeting, one hundred dollars of the balance on hand was deposited to the credit of the Branch in the Savings Department of the First National Bank of Atlanta, Ga.

At a business session of the Branch in 1928, annual dues of $1.00 were established. Fifty-eight members have paid their 1929 dues, 60 have paid their 1930 dues, 63 have paid their 1931 dues, and 24 have paid their dues for last year. Only 3 members have paid their 1933 dues which are now payable.

The Publications Committee called attention to the fact that an abstract must accompany all papers presented for publication in the proceedings of the Branch.

Chairman Folsom announced the committee appointments as follows: Auditing—F. F. Bondy, F. L. Thomas and L. L. English. Executive: Clay Lyle (pro-tem.). Nominations: Clay Lyle, K. L. Cockerham, and F. L. Thomas. Resolutions: W. E. Hinds, T. E. Holloway and R. K. Fletcher. Publications (standing): Oliver Snapp and Herbert Spencer.

Final Business

The final business was transacted on the afternoon of February 3. Chairman Folsom called for the reports of committees.

The Auditing Committee reported that the books and accounts of the Branch had been carefully audited and found to be correct. This report was then adopted by motion and vote and a certificate from the committee given to the Secretary-Treasurer.

The following resolutions were duly adopted after the reading of the report of the committee on resolutions:

Whereas, We, the members of the Association of Cotton States Entomologists now meeting in the city of New Orleans, La., have enjoyed a very profitable and

satisfactory annual meeting, and desire to record and to extènd the appreciation which we feel to those who have helped to make this gathering a success.

Therefore, Be it Resolved, That our appreciation and thanks be extended to Mr. T. F. Catchings and Mr. A. W. Cressman for the arrangements and menu, to florist E. A. Farley for flowers and to Dr. J. W. Folsom for entertainment, all in connection with the entomologists' dinner enjoyed at Broussards Restaurant, to Mr. T. E. Holloway for the supply of a stereopticon and to the New Orleans entomologists for all of their generous hospitality, including the tour of the city, which we have all enjoyed throughout this gathering.

By unanimous vote of the executive committee called for by the chairman several weeks before the New Orleans meeting, an appropriation of twenty-five dollars was made to defray a part of the expenses of the Secretary-Treasurer in attending the eighth annual meeting. The executive committee also voted that hereafter the expenses of the secretary-treasurer in attending the annual meetings shall be paid out of the treasury, or that at least a part of his expenses shall be so paid, the amount depending upon the condition of the treasury at the time and the discretion of the executive committee.

The Nominations Committee presented the following names for officers during the ensuing year: Chairman—R. W. Leiby, Raleigh, N. C., Vice Chairman—S. W. Bilsing, College Station Texas. These officers were duly elected by motion and vote. Secretary-Treasurer Oliver Snapp was elected in 1931 for a three-year term.

The matter of changing the name of the Branch to Southern States Branch came up for final action. A number of reasons for retaining the old name were advanced by those in attendance, and by motion and vote it was decided that the Branch will continue under the name of Cotton States Branch.

By motion and vote the executive committee was authorized to select the place and time for the next annual meeting.

PART II. PAPERS

The session for addresses and presentation of papers convened immediately following the business session with Chairman Folsom presiding.

THE ECONOMIC IMPORTANCE OF COLLEMBOLA

By J. W. Folsom, *Senior Entomologist, Division of Cotton Insects, U. S. Bureau of Entomology*

Abstract

The most serious kinds of damage by springtails are described. All the known injurious species are listed.

The list of injurious species of Collembola, or springtails, is constantly growing. This article lists all the species that are known to be injurious up to the present, and supplements the previous summaries given by Theobald (1911), Collinge (1909, 1910), and Mills (1930)

Collembola are so small that their depredations are often overlooked or attributed to other causes. At times, however, they make up for their small size by immense numbers They multiply rapidly under favorable conditions, chief of which are humidity and temperature, as expressed in power of evaporation. Collembola soon dry up in a dry atmosphere, and can resist high temperatures only in the egg stage.

The organic matter that forms the food of springtails is obtained from many different sources, as Macnamara (1924) has described in a most readable account. Most springtails are vegetarians

Nature of Damage.—The greatest damage by springtails is done to young, tender plants, especially to seedlings Some species prefer the upper or the lower surface of a leaf to work on, whereas other species work on either surface The springtails make irregular holes in leaves, gradually piercing the leaf completely, or characteristically leaving the epidermis at the end of the puncture intact They feed also at wounds made by flea beetles, potato beetles, and other insects Sometimes they completely destroy cotyledons and other leaves. In many instances springtails feed collectively, several or many individuals cooperating to enlarge the same opening. Of course, the wounds that they make cause the plant to bleed, and afford entrance to fungi and bacteria.

Many species injure the stems of plants just below the surface of the ground and often cut through them. On roots springtails cause injury by gnawing pits and by destroying root hairs and small rootlets. As a result, the growth of a plant may be stunted. On seeds these insects do more or less damage by eating out pits. On bulbs they not only make pits but also excavate the interior, sometimes completely.

Injury to Truck Crops.—In North America a single species of Collembola, *Bourletiella hortensis* (Fitch), has become sufficiently important to receive a popular name—the garden springtail. It is a common species every year and can usually be found on flowers of dandelion.

In occasional years it appears in enormous numbers and becomes a pest of great, though local, importance on seedlings. In May, 1922, as reported by Dr. H. T. Fernald (Brittain, 1924), it raised havoc with onions in Massachusetts, ruining them by eating holes in the leaves and killing 55 per cent of the plants. It has often damaged seedling cucumbers, cabbages, and beets so severely, by eating the leaves and cutting through the stems, that replanting was necessary. In 1920 in Nova Scotia it withered entire fields of mangolds and turnips, almost in a day. One turnip field had to be seeded three times. The same species has been destructive in England (Davies, 1926).

INJURY TO FIELD CROPS.—A related species, *Sminthurus viridis* (L.), "is the most important insect pest of field crops in South Australia today" (Holdaway, 1927). It has several times occurred in countless millions in alfalfa fields. On alfalfa a severe attack gives the field a scorched appearance This "lucerne flea," as it is called, damages the foliage of many winter fodder plants, particularly alfalfa and clovers, and attacks wheat, oats, and barley as soon as they are through the ground Its list of food plants includes more than thirty species of cultivated plants, among which are all the common garden vegetables (Holdaway, 1927; Davies, 1928). In the United States, such extensive damage to cereal and forage plants by springtails has been unknown.

INJURY TO SUGARCANE.—Spencer and Stracener (1928, 1929, 1930) proved that several species of Collembola eat pits in the roots of sugarcane. These species are *Pseudosinella* (*Lepidocyrtus*) *violenta* (Fols), *Onychiurus armatus* (Tull), and possibly *Proisotoma minuta* (Tull). *P. violenta* is the worst offender, for it also eats off almost all the fine hairy side roots. The absorption of water and food is greatly hampered by the destruction of secondary roots; consequently the sprout growth was found to average 14 per cent less in affected plants than in unaffected check plants. This kind of root injury is prevalent in all the sugarcane parishes of Louisiana.

The same authors found that *P. violenta* and *O. armatus* (with some assistance from *Symphylella* sp.) caused a marked reduction in the growth and final weight of sugarcane plants, and a slight reduction in the percentage of sucrose. The springtails also impaired germination by eating portions of the buds and bud scales.

Ingram (1931) observed *P. violenta* grazing upon the root hairs of the cane plant. He found also that *Lepidocyrtus cyaneus* Tull. feeds upon a fungus that grows upon sugarcane.

In Hawaii (Muir, 1926; Van Zwaluwenburg, 1926, 1927; Williams, 1931) root tips of sugarcane are heavily pitted by a species of *Isoto-*

modes, which occurs sometimes in immense numbers in the soil. This pitting results in short and stunted roots, which are inadequate for the needs of normal plant growth. The same species works also on pineapple roots.

INJURY TO MUSHROOMS.—In the United States, springtails are pests of major importance on cultivated mushrooms. The chief culprit in this respect is *Achorutes armatus* (Nic.), but other species of *Achorutes*, *Xenylla*, *Schottella*, and *Isotoma*, along with *Lepidocyrtus cyaneus* and *Sinella hofti* Schaf. are also concerned. All these are soil species, which normally feed on wild agarics and other fungi and which transfer their attacks easily to cultivated mushrooms. These springtails are usually carried into the house with manure (Thomas, 1932), and finding optimum conditions of moisture and temperature, they reproduce rapidly to enormous numbers. They eat the mycelium and may destroy it entirely. Hundreds may gather on a single mushroom and riddle the cap and stem with holes, which give access to fungi and bacteria that cause decay In one instance, in St Louis, a mushroom bed 150 feet long was honeycombed and destroyed by springtails

CONTROL.—"A high percentage of kill has been obtained by the use of a two or three per cent free nicotine-lime dust." (Thomas, 1932) This kills most of them very quickly Naphthalene and paradichlorobenzene are very toxic to springtails. Excellent control on mushrooms has been had by nicotine fumigation Pyrethrum is not so effective. In fields the use of tobacco dust and of air-slaked lime has given good results.

Dryness and high temperatures are, of course, fatal to springtails.

Of some 2,000 species of Collembola that have been described, only about 40 are as yet known to be injurious.

Collembola are of minor economic importance but are of more importance than is generally known.

LIST OF INJURIOUS SPECIES OF COLLEMBOLA

Achorutes armatus (Nic.) A major pest in mushroom beds. Attacks fern roots, narcissus bulbs and bean seeds, seedling beans, peas, and sugar beets. In 1924 it damaged lawns at Miami, Ariz.

Achorutes humi Fols. Found on well water.

Achorutes longispinus Tull. Damages bean seeds and seedlings.

Achorutes macgillivrayi Fols. Injurious in very great numbers in greenhouses.

Achorutes manubrialis Tull. Abundant and injurious in cold frames. Often does great damage to seedling cucumbers, melons, and cauliflower.

Achorutes maturus Fols. In great numbers damaging mushrooms in houses and caves.

Achorutes purpurescens Lubb. Gnaws roots and crowns of young cabbage plants. May kill weak plants.

Achorutes socialis Uzel. Contaminates maple sap.

Achorutes viaticus Tull. Has been beneficial in removing organic deposits from a sewage filter in England.

Allacma fusca (L.). In Theobald's list.

Anurida granaria (Nic.). In Theobald's list.

Bourletiella arvalis (Fitch). Eats pollen of raspberry.

Bourletiella hortensis (Fitch). Sporadically very destructive to truck crops in North America. Food plants: bean, beet, cabbage, cantaloupe, carrot, cauliflower, clover, corn, cucumber, horseradish, kale, lettuce, mangold, onion, pea, potato, pumpkin, radish, rape, rye, soy bean, spinach, squash, sweet peas, tobacco, tomato, turnip, violet, watermelon, wheat, wild cucumber, wormseed. Eats egg masses of the Colorado potato beetle.

Bourletiella lutea (Lubb.). In England it injures young potato tops and turnip leaves. Has done great damage to red currant, feeding on leaves and shoots, and causing the fruit to fall off.

Entomobrya multifasciata (Tull.). Eats pollen of barberry, also spores of fungi.

Entomobrya nivalis (L.). Swarms on currant and feeds on the leaves; in England, damages hops severely.

Folsomia fimetaria (L.). Often so abundant on the surface of well water as to be a nuisance; injures roots of sugarcane.

Folsomia nivalis (Pack.). Abundant in one well.

Heteromurus nitidus (Templ.). May kill strawberry plants, by feeding on roots and bases of leaves (England).

Isotoma sp. Torments poultry; abundant in old nests (England).

Isotomodes denisi Fols. In Hawaii, damages sugarcane roots seriously; also injures pineapple roots.

Isotomurus palustris (Mull.). Injures roots of sugarcane.

Lepidocyrtus cyaneus Tull. Damages mushrooms. Feeds upon a fungus of sugarcane.

Lepidocyrtus violentus. See *Pseudosinella violenta* (Fols.).

Onychiurus ambulans (L.). Injures beans, peas, cauliflower, etc., by eating roots and stems under ground; damages leafstalks of celery; eats into bean seeds; ruins narcissus bulbs.

Onychiurus armatus (Tull.). Attacks seedlings of pea, bean, and sugar beet; injures roots and buds of sugarcane; damages ferns.

Onychiurus fimetarius (L.). Often occurs in swarms, feeding on roots of carrots, potatoes, etc., in damp soil; injures roots of sugarcane.

Onychiurus pseudarmatus Fols. Injurious to roots of newly sown wheat and to roots of vetch.

Onychiurus ramosus Fols. Found on well water.

Orchesella cincta (L.). Destroys seeds and bulblets of orchids.

Podura aquatica L. Five specimens were taken from the stomach of a toad, *Bufo americanus*.

Proisotoma minuta (Tull.). Possibly injurious to roots of sugarcane.

Proisotoma tenella (Reut.). In multitudes on tobacco seedlings, which they destroy.

Pseudosinella violenta (Fols.). Causes serious injury to roots of sugarcane. Damages roots of beets.

Sinella höfti Schäf. Does commercial damage to mushrooms. In one instance caused serious damage to lilies in a greenhouse.

Sira buski Lubb. Infests houses. Feeds on garbage.

Sira nigromaculata Lubb. Infests houses, occasionally becoming a nuisance. Feeds on garbage.

Sminthurides aquaticus (Bourl.). Eaten in large numbers by young brook trout.

Sminthurides malmgreni (Tull.). Eaten in large numbers by young brook trout.

Sminthurinus niger (Lubb.). Injurious, according to Theobald.

Sminthurus sp. Feeds on, and distributes, uredospores of the wheat rust.

Sminthurus viridis (L.). A serious pest of cereal and forage crops in South Australia.

Xenylla humicola (O. Fab.). Often injurious to mushrooms.

References

Only the most important titles are given here, but the addition of the references contained in these articles will give an almost complete bibliography of the subject.

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PROGRESS REPORT ON THE DEVELOPMENT OF THE BOLL WEEVIL ON PLANTS OTHER THAN COTTON

By R. C. Gaines, *Entomologist, U. S. Bureau of Entomology, Tallulah, La.*

ABSTRACT

Boll weevils developed to sexual maturity on cultivated althea (*Hibiscus syriacus* L.) and deposited eggs normally in the buds of this plant. Three female weevils developed in, and emerged from, buds of althea. Boll weevil eggs, some of which hatched, were deposited externally on the seed pods of *Hibiscus militaris* Cav. and *H. lasiocarpus* Cav. Larvae that hatched from eggs deposited externally were placed in seed pods of these plants, but soon died, leaving no evidence of feeding. No eggs were deposited on hollyhock (*Althaea rosea* Cav.) or okra (*Hibiscus esculentus* L.).

The original food plants of the boll weevil (*Anthonomus grandis* Boh.) are the tree cottons of Guatemala, Mexico, and Cuba (*4, p 31*). The native food plant of the Thurberia weevil (*Anthonomus grandis thurberiae* Pierce) is the so-called Arizona wild cotton (*Thurberia thespesioides*) found growing in Arizona, parts of Mexico, and New Mexico (*2, p. 3–4*). The normal food plants of the boll weevil are the cultivated and other cottons belonging to the genus *Gossypium*. In 1913, after the discovery of a boll weevil feeding on cultivated althea (*Hibiscus syriacus* L.) at Victoria, Tex., Coad (*1*) reared two male boll weevils in buds of this plant, noted the partially complete development of the weevil in the buds of two plants belonging to the genus *Callirrhoe* (*C. involucrata* Gray and *C. pedata* Gray), and kept weevils alive for a short period on buds of *Sphaeralcea lindheimeri* Gray. Boll weevils have deposited eggs normally in okra buds and small fruit, but the larvae failed to survive on this food (*3, p. 8–9*) Boll weevils were noted to feed and to deposit eggs externally on the seed pods of several plants belonging to the genus *Hibiscus* (*4, p. 31–32*) and in one instance (*3, p. 10–11*) an egg was deposited normally.

Since legislation to prohibit the planting of cotton during 1932 was considered in several states, evoking widespread interest in the question as to whether the elimination of cotton might result in extermination of the boll weevil, it was deemed advisable to re-investigate the possibility that the boll weevil might develop on plants other than cotton.

The boll weevils used in tests were from three sources—those carried through hibernation, those reared, and those collected in the field. The hibernated weevils had emerged from hibernation in cages, the reared weevils had emerged from cotton squares placed in breeding cages, and the field-collected weevils were from cotton plants growing in the field. Tests were conducted on five species of malvaceous plants growing in

the open field, and with buds, blooms, and seed pods of these plants in the insectary. Tests in the open field were made by confining a definite number of weevils in small organdie sacks on certain portions of a growing plant, and by placing 18 inch by 18 inch by 36 inch screen-wire cages over growing plants to confine the weevils. In the insectary, lantern globes, tumblers, and screen-wire cages about 3 inches in diameter and 3 inches high, with one end open, were used to confine the weevils. The lower, open end of a lantern globe was placed on moist sand, the other end being covered with cheese cloth or screen wire; the tumblers were partly filled with moist sand and covered with cheese cloth or screen wire; and the open end of each small screen-wire cage was pushed into moist sand. The buds, blooms, and seed pods used in lantern-globe, tumbler, and small screen-wire cage tests were placed in small vials of water so that they would remain fresh for a longer time.

TESTS WITH HOLLYHOCK (*Althaea rosea* Cav.).—Hollyhock is grown as an ornamental The plants bloom and set a seed crop during the spring and early summer and then die down. A total of 18 tests were conducted with hibernated and with reared weevils in the open field, and in the insectary on hollyhock buds, blooms, and seed pods. One weevil was observed feeding on a young seed pod, and there was some evidence of feeding on one bud; otherwise there was no evidence of feeding, and no eggs were deposited. During June the average longevity of 24 hibernated weevils fed on hollyhock blooms and buds was 9.8 days, the longevity range being from 4 to 16 days.

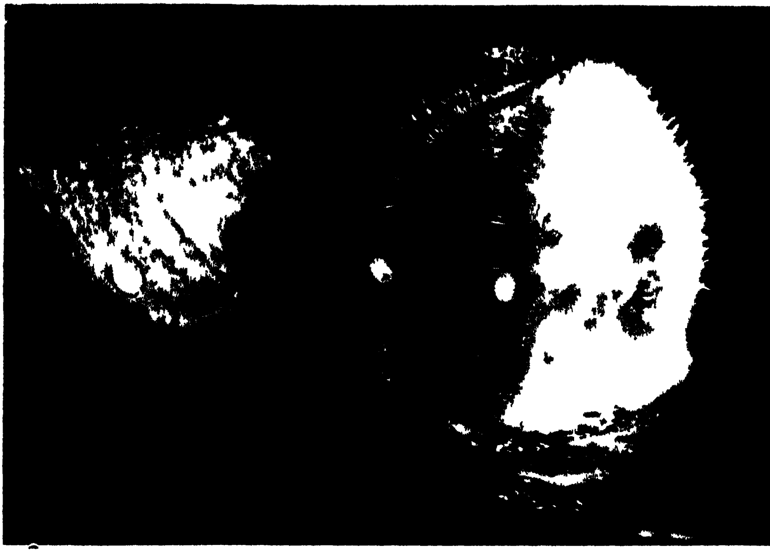
TESTS WITH OKRA (*Hibiscus esculentus* L.).—This cultivated plant is grown generally and is often found in cotton fields or in small garden patches adjoining cotton. A total of nine tests were made on okra with hibernated, reared, and field-collected weevils in the open field and in the insectary. In these tests there was no evidence of feeding, and no eggs were deposited. In August six field-collected weevils lived an average of 5.3 days on young seed pods.

TESTS WITH *Hibiscus lasiocarpus* Cav.—This plant is fairly abundant in Madison Parish, Louisiana in rather low, moist places, such as bayou banks and roadside ditches, and fruits throughout most of the summer. A total of 11 tests were conducted with reared and with field-collected weevils, in the open field and in the insectary. On August 9 seven pairs of field-collected weevils were placed in three tumblers and four small screen-wire cages in the insectary. A young seed pod was placed in each tumbler and cage. From August 9 to 15 a total of nine eggs (three of which are shown in Plate 42, figure 1) were found to have been deposited externally by the seven females. Eight were found on the seed pods and

one on the calyx. Two of these eggs hatched. The young larvae were immediately placed in seed pods but both died in a short time, leaving no evidence of feeding. No eggs were deposited normally. Of the 14 weevils used in this series of tests only 1 lived longer than 6 days; the 13 other weevils lived an average of 4.5 days on seed pods. In some tests weevils were found to feed freely on the blooms and seed pods of this plant, while in others they did not feed, or fed sparingly on the seed pods.

TESTS WITH *Hibiscus militaris* Cav.—This plant is not so common as *H. lasiocarpus* but is found growing under the same conditions. A total of 42 tests were made with hibernated, reared, and field-collected weevils, in the open field and in the insectary. Weevils were found to feed freely on the buds, blooms, and seed pods of this plant. In these tests a total of five eggs were found to have been deposited externally on seed pods by field-collected weevils, and one newly hatched weevil larva was found on the calyx of a seed pod. This larva was immediately placed in a seed pod but soon died, leaving no evidence of feeding. No eggs were found deposited normally.

TESTS WITH *Hibiscus syriacus* L.—This plant is grown quite generally as an ornamental and is a woody perennial commonly called althea. A total of 21 tests on althea were made with hibernated and with reared weevils, in the open field and in the insectary. Weevils fed freely on buds and blooms of this plant. During August 14 of the 18 reared weevils used in one series of tests in the insectary lived an average of 5 days on althea buds. The 4 other weevils lived longer than 7 days. On the 15th of August 20 weevils, 10 females and 10 males, reared from cotton squares were released in a screen-wire cage over a growing althea plant. These weevils had not been permitted to feed on cotton or any other plant before being released in this cage. On August 29 the shed buds and blooms were collected from the floor of the cage and placed in a breeding cage in the insectary for observation. On September 12, 17 (Plate 42, figure 2), and 19, female weevils emerged from three of these althea buds. These three female weevils, paired with three males reared from cotton squares, were immediately placed in three small screen-wire cages over moist sand in the insectary. A fresh supply of althea buds and blooms was kept in these cages at all times. The female weevil that emerged from an althea bud on September 12 escaped on October 12, the female that emerged on September 17 was found dead on October 25, and the female that emerged on September 19 was found dead on October 24. The longevity of these three females was 30+, 38, and 35 days, respectively. These weevils fed freely on althea buds and blooms but no eggs were found to have been deposited by any of the females.



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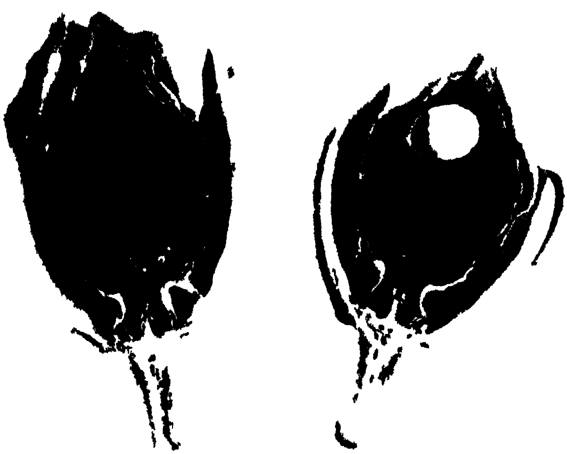

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1.—Three boll weevil eggs deposited externally on calyx and seed pod of *Hibiscus lasiocarpus*. Weevil feeding puncture to the right of eggs on seed pod.

2.—Althea (*Hibiscus syriacus*) bud in which female boll weevil developed and from which it emerged on September 17, 1932. Bud halved to show weevil cell and exit hole.

SUMMARY.—Boll weevils fed freely on buds and blooms of althea (*Hibiscus syriacus*). Weevils fed freely on buds, blooms, and seed pods of *Hibiscus militaris* and fed on blooms and seed pods of *Hibiscus lasiocarpus*. Weevils fed very sparingly on buds and seed pods of hollyhock (*Althaea rosea*) and were not observed to feed on okra (*Hibiscus esculentus*), though very few tests were made with okra.

Boll weevil eggs, some of which hatched, were deposited externally on the calyx and on the seed pods of *Hibiscus militaris* and *H. lasiocarpus*. The female weevils that deposited these eggs had developed to sexual maturity on cotton and in no case did female weevils become sexually mature on either of these plants. No weevil eggs were deposited on hollyhock or okra. Weevil eggs were deposited normally in althea buds. The females depositing these eggs had developed to sexual maturity on althea. Three female weevils developed in and emerged from althea buds.

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THE EFFECT OF CERTAIN HOMOPTEROUS INSECTS AS COMPARED WITH THREE COMMON MIRIDS UPON THE GROWTH AND FRUITING OF COTTON PLANTS

By K. P. EWING, and R. L. MCGARR, *Division of Cotton Insects, U. S. Bureau of Entomology, Tallulah, La.*

ABSTRACT

Three years of cage experiments with four homopterous insects (*Homalodisca triquetra, Oncometopia undata, Graphocephala versuta,* and *Stictocephala festina*) showed that none of these species, when allowed to feed on cotton plants, was able materially to reduce the normal production of fruit of the plants, or cause typical hopper damage, as did three species of mirids (*Psallus seriatus, Lygus pratensis,* and *Adelphocoris rapidus*).

The intensive investigations that have been conducted on the cotton flea hopper, *Psallus seriatus* Reut., during the last few years, have naturally led to investigations on certain other miscellaneous cotton insects.

Previous cage experiments (*1*)[1] showed that three mirids commonly found on cotton, namely, *Psallus seriatus* Reut., *Lygus pratensis* L., and *Adelphocoris rapidus* Say, as well as three other mirids, *Creontiades debilis* V. D., *Poeciloscytus basalis* Reut., and *Lygus apicalis* Fieb., found on cotton only occasionally, are each capable of producing what is commonly called "hopper damage;" that is, they cause dying or abortion of the small squares or floral buds, thus materially reducing the number of live forms that would ordinarily be present on the plants.

In making sweepings to determine the degree of infestation by hoppers in cotton it has been observed that certain homopterous insects were often present in fairly large numbers in many localities in the Cotton Belt. In 1929 and 1930 sweepings were made in a number of cotton fields scattered over Madison Parish, La , and the abundance of four species of homopterous insects and two species of mirids was recorded. The greatest number of each species collected per 100 sweeps in June, July, and August is recorded in Table 1

TABLE 1. SWEEPING RECORDS SHOWING ABUNDANCE OF TWO MIRIDS AND FOUR HOMOPTEROUS INSECTS ON COTTON IN MADISON PARISH, LA., 1929 and 1930[1]

	Maximum number of insects collected per 100 sweeps					
	1929			1930		
Name of insect	June	July	August	June	July	August
Lygus pratensis	16	6	9	18	14	2
Adelphocoris rapidus	3	5	10	4	5	3
Homalodisca triquetra	53	29	27	3	8	5
Oncometopia undata	22	3	3	0	3	0
Graphocephala versuta	58	49	37	52	42	26
Stictocephala festina .	12	3	1	3	3	2

[1]These records were made by L. W. Noble, L D. Christensen, J G. Shaw, and E. E. Rogers.

Two of these homopterous insects, *Homalodisca triquetra* Fab. and *Oncometopia undata* Fab., were observed and commented on by several of the earlier cotton insect investigators. In 1897 L O. Howard (*2*) wrote as follows: "There is a class of damage to the bolls which is known to planters as 'sharpshooter work,' which is mainly caused by the punctures of a leaf hopper known as *Homalodisca coagulata*."[2]

F. W. Mally wrote to E. D. Sanderson (*3, p. 54*): "Replying to your favor of August 11 (1904), making inquiry concerning my observations upon *Homalodisca coagulata* (*triquetra*), I beg to state as follows: * * * the very young are often found in the bud, so-called, of the tender growing tips of the branches on cotton. It is here, while the leaf buds and fruit buds are bunched together and in a formative condition, that the most

[1]Italic numbers in parenthesis refer to Literature Cited at the end of this paper.
[2]Later named *triquetra*.

serious damage is done. The feeding punctures are often not serious enough to shed the squares until they grow out and attain some size."

Sanderson sums up his observations on *Homalodisca triquetra* as follows: "* * * we are forced to conclude that the possible injury to the cotton plant from this insect and those to be discussed below which might easily be confused with it[3] is inconsiderable."

Observations of earlier entomologists differ somewhat on the probable damage to cotton from *H. triquetra* and *O. undata*. There are no specific data published showing definitely whether or not these insects can cause cotton plants to shed their fruit. Since investigations in recent years have implicated several species of mirids in "hopper damage," it was deemed advisable to determine positively whether certain of the Homoptera commonly found abundant in cotton fields were capable of producing a similar damage. The necessity for these investigations increased as inquiries regarding this became more numerous.

A preliminary experiment was conducted in 1928 to ascertain whether it would be possible to work with this group of insects under cage conditions. In this experiment the homopterous insects under observation behaved more normally under cages than did the mirids.

Cage experiments were started in 1929 and continued through 1931 with four of these insects, *Homalodisca triquetra*, *Oncometopia undata*, *Graphocephala versuta*, and *Stictocephala festina*, to compare their possible damage with that caused by three mirids, namely, *Psallus seriatus*, *Lygus pratensis*, and *Adelphocoris rapidus*. The above-named Homoptera were chosen because of their abundance on cotton during the growing season.

The methods of experimentation during each year, 1929, 1930, and 1931, were essentially the same, with the exception that in 1929 the cages were constructed of 16-mesh wire screen or of cloth and glass, whereas in 1930 and 1931 they were constructed of 16-mesh or 24-mesh screen.

In 1929 comparisons were made of different cages to determine under which type a cotton plant would make the most normal growth. Five types of cages were used, constructed of the following materials: "Cloth-glass," "celo-glass," 16-mesh galvanized screen, 24-mesh brass screen, and cloth and glass. Temperature and humidity records made in the cages gave a good basis for comparisons. On account of the fact that the 24-mesh screen cage was not constructed until late in the season, only temperature records for comparing the 24-mesh screen with the 16-mesh screen were made in this cage. Table 2 gives the results of the humidity

[3]He refers here to *Oncometopia undata*.

and temperature readings made in the five types of cages experimented with in 1929. These records, as well as observations on the normal growth and fruitage of the cotton plants in the cages, showed that the screen cages were the most suitable for the experiments. It was also noted that for all practical purposes there was no difference in the growth and fruitage of the plants grown in the 16-mesh galvanized screen cage compared with those in the 24-mesh brass screen cage.

TABLE 2. COMPARISON OF TEMPERATURE AND HUMIDITY RECORDS IN CAGES OF DIFFERENT TYPES. TALLULAH, LA., 1929

		Temperature			Humidity		
Type of cage	Dates of records	Morning (8.00-9.00 a.m.)	Noon (11.30 a.m.-1.00 p.m.)	Evening (4.30-6.00 p.m.)	Morning (8.00-9.00 a.m.)	Noon (11.30 a.m.-1.00 p.m.)	Evening (4.30-6.00 p.m.)
Open air	July 13 to Aug. 16, incl.	—	—	—	76.9	64.5	66.2
16-mesh screen	July 13 to Aug. 16, incl	81.6	89.4	87.2	76.1	63.5	66.4
"Cloth-glass"	July 13 to Aug. 16, incl.	86.7	94.7	92.4	74.3	61.7	66.7
"Celo-glass"	July 13 to Aug. 16, incl	87.6	95.9	92.6	72.6	60.4	63.7
Cloth and glass	July 13 to Aug. 16, incl	95.4	106.3	99.2	70.0	57.1	64.9
16-mesh screen	Oct. 15 to 29, incl.	66.6	79.7	70.4	—	—	—
24-mesh screen	Oct. 15 to 29, incl.	65.9	78.7	70.5	—	—	—

The 24-mesh screen was sufficiently fine to retain the smallest insect used, *Psallus seriatus*. On account of the initial cost of the 24-mesh brass screen only about one-half of the cages were covered with this material, and the remainder were constructed of 16-mesh galvanized screen. In each series of experiments during 1930 and 1931, the mirids were confined under 24-mesh cages and the Homoptera under 16-mesh cages.

The details of the experiments of only one year (1931) will be discussed here, with a general summary given of the results during the other two years (1930 and 1929).

In 1931 the cotton for the experiments was planted on May 26, on the experimental plot in the rear of the laboratory buildings, 2½ miles south of Tallulah, La. The variety of cotton used was Delfos 6102-38, Strain 2. The cages were placed over the cotton soon after it was "chopped" and about 10 days before the experiments were started. The plants for each cage were selected with a view to their being as nearly uniform as possible, and three were inclosed in each cage. The uniformity of the soil was also considered in selecting the plants for the

cages. All plants were dusted with a heavy application of nicotien sulphate, immediately after being caged, to kill all aphids. Care was taken throughout the experiments to see that no insect other than the one introduced had access to the plants under observation.

A total of 16 cages were used in this series of experiments, two cages for each of the following insects: *Lygus pratensis*, *Adelphocoris rapidus*, *Psallus seriatus*, *Homalodisca triquetra*, *Oncometopia undata*, *Graphocephala versuta*, and *Stictocephala festina*, and two check cages. The insects were introduced into their respective cages on June 30, at which time a record was made of the live forms present on the plants and the height of the plants. Inspections of the plants were made at 2 or 3 day intervals to note the forms that were shed, and weekly examinations were made to determine the live squares and bolls present on the plants, and the plant heights. All of these records were summarized and are shown in Tables 3 and 4 as weekly interval readings. As each cage contained 3 cotton plants, the figures shown in Tables 3, 4, 5, and 6 are the averages of 6 plants for each insect listed as well as for the checks.

TABLE 3. WEEKLY EXAMINATIONS SHOWING THE NUMBER OF LIVE FORMS ON THE PLANTS AND PLANT HEIGHTS IN THE CHECK CAGES AS COMPARED WITH THE PLANTS EXPOSED TO EACH OF THE THREE SPECIES OF MIRIDS AND FOUR SPECIES OF HOMOPTEROUS INSECTS. EACH RECORD IS AN AVERAGE OF 6 COTTON PLANTS. TALLULAH, LA., 1931

Date	Check	Lygus pratensis	Adelphocoris rapidus	Psallus seriatus	Homalodisca triquetra	Oncometopia undata	Graphocephala versuta	Stictocephala festina
				Live forms present				
				Squares				
June 30	1.9	2.0	2.0	1.2	2.7	2.2	2.3	2.7
July 7	9.0	1.9	4.4	6.9	12.9	10.7	11.9	10.7
July 14	20.5	2.2	8.0	14.7	25.7	21.0	26.0	19.5
July 21	31.2	1.9	10.2	16.9	30.5	32.4	33.2	28.7
July 28	38.4	1.2	7.0	18.4	38.2	40.5	46.4	25.3
Aug. 4	48.9	1.0	7.8	17.5	49.4	51.0	58.2	34.0
				Bolls				
June 30	0	0	0	0	0	0	0	0
July 7	0	0	0	0	0	0	0	0
July 14	0	0	0	0	0	0	0	0
July 21	0	0	0	0	.7	.7	.5	.5
July 28	3.0	0	0	1.9	5.2	4.2	3.2	2.8
Aug. 4	8.2	.2	.7	5.9	9.0	9.7	9.3	7.9
				Plant height (inches)				
June 30	8.9	10.5	8.5	8.9	10.0	9.2	9.5	9.8
July 7	14.3	12.0	12.0	13.5	15.0	14.7	15.2	15.8
July 14	21.7	14.5	18.4	20.0	20.7	21.0	22.4	20.5
July 21	30.5	19.4	26.3	28.3	27.2	29.2	31.5	25.3
July 28	38.7	24.0	33.5	34.5	32.5	36.0	40.0	30.0
Aug. 4	48.0	30.7	42.0	43.0	37.9	42.5	46.4	34.0

Previous experiments had shown that the mortality of these insects, especially the mirids, when confined under a large cage was comparatively high: also, that they did not reproduce enough to keep up a normal infestation on the cotton plants. Consequently additional insects were introduced at irregular intervals from June 30 to August 4, to keep the average infestation of each species in the cages up to a standard, which might ordinarily be called a "heavy field infestation."

For example, 32 introductions were made in the cages containing *A. rapidus* with an average total of 197.5 insects introduced per plant during the experiment In the case of *H. triquetra*, 14 introductions were made with an average total of 108 7 insects introduced per plant from June 30 to August 4. As a whole the mortality of the homopterous insects, especially *O undata* and *H. triquetra*, was considerably below that of the mirids. In the case of *H triquetra*, which was the insect easiest to handle and count inside the cages, the average population per plant ranged from about 10 to 25.

On June 30, when the experiment started, the plants exposed to the different species of insects were entirely comparable, both as to height and live squares present. (Table 3.) The live squares per plant ranged from a minimum of 1.2 in the *P seriatus* cages (all figures referring to the plant data of 1931 are the average of 6 plants) to a maximum of 2.7 in the *H. triquetra* and *S. festina* cages, respectively. The plant heights ranged from 8 5 inches in the cages containing *A. rapidus* to 10.5 inches in the cages containing *L. pratensis*.

The live squares and bolls (blooms counted as bolls) and plant heights as determined at weekly intervals from June 30 to August 4 are shown in Table 3. The dead forms removed, including "hopper squares" and naturally shed squares and bolls, are recorded in Table 4. It may be well to state here that the term "hopper square" refers to the small floral buds, or squares, that are blasted by the feeding of plant-sucking insects. These squares range in size from as small as an ordinary pinhead to about 4 or 5 millimeters in width. Vigorous cotton plants growing under favorable conditions and without adverse outside influence do not ordinarily shed squares at this stage. Often, when cotton plants reach maturity with a full crop of bolls and large squares on them or when droughts, lack of plant food, or other factors cause an unfavorable physiological condition, they will naturally shed a certain number of small squares. These small naturally shed squares can usually be distinguished from hopper squares. They are a little larger than the usual hopper square; the smallest being as large as, or larger than, the largest hopper square. Moreover, they are usually yellow, like ordinary

weather-shed forms, especially when removed from the plant within a day or two after dying; whereas the hopper squares are usually dark brown or black when shed. In these experiments there were a few small naturally shed squares removed from most of the plants that retained any considerable amount of their fruit, in which instances these shed squares are recorded as naturally shed squares or forms.

TABLE 4. WEEKLY EXAMINATIONS SHOWING THE NUMBER OF HOPPER SQUARES AND NATURALLY SHED SQUARES AND BOLLS REMOVED FROM THE CHECK CAGES AS COMPARED WITH REMOVALS FROM CAGES CONTAINING THE THREE SPECIES OF MIRIDS AND FOUR SPECIES OF HOMOPTEROUS INSECTS. EACH RECORD IS AN AVERAGE FROM 6 COTTON PLANTS. TALLULAH, LA., 1931

Date	Check	Lygus pratensis	Adelphocoris rapidus	Psallus seriatus	Homalodisca triquetra	Oncometopia undata	Graphocephala versuta	Stictocephala festina
				Dead forms removed Hopper Squares				
June 30	0	0	0	0	0	0	0	0
July 7	0	4.9	1.8	0	0	0	0	0
July 14	0	4.3	2.9	1.2	0	0	0	.5
July 21	0	5.2	6.7	6.2	0	0	0	1.0
July 28	0	8.0	7.3	5.4	0	0	0	3.0
Aug. 4	0	6.0	5.7	7.4	0	0	0	1.2
Total	0	28.4	24.4	20.2	0	0	0	5.7
				Naturally shed Squares				
June 30	0	0	0	0	0	0	0	0
July 7	.3	0	0	.2	0	0	0	0
July 14	.2	0	0	0	0	0	0	0
July 21	.4	0	.4	0	0	.3	0	.9
July 28	.2	.5	1.0	1.2	.5	.2	0	2.3
Aug. 4	1.0	1.0	1.9	1.0	.4	.4	.5	.7
Total	2.1	1.5	3.3	2.4	.9	.9	.5	3.9
				Bolls				
June 30	0	0	0	0	0	0	0	0
July 7	0	0	0	0	0	0	0	0
July 14	0	0	0	0	0	0	0	0
July 21	0	0	0	0	0	0	0	0
July 28	0	0	.2	0	.4	.5	.7	.2
Aug. 4	.3	0	0	.5	1.9	.5	1.0	.5
Total	.3	0	.2	.5	2.3	1.0	1.7	.7

Later experiments have shown that *Lygus pratensis* and *Adelphocoris rapidus* are capable of causing large squares to shed. It should be remembered, however, that in this group of experiments the insects started feeding on the plants before the squares reached any appre-

ciable size, consequently the damage was done primarily to the small squares just as they were being formed.

In fact, as will be noted from Table 4, there were very few naturally shed squares (including both small and large) taken from any of the cages in 1931; the lowest average being 0.5 from the cages containing *G. versuta* and the highest 3.9 from the *S. festina* cages.

Table 5 gives a summary of the results of the series of experiments of 1931. It will be noted that the plants in the check cages bore an average of 1.9 live forms at the beginning of the experiment and 57.1 forms at the conclusion, and that the average in the cages of *L. pratensis* fell from 2.0 at the beginning to 1.2 at the conclusion. The cages containing *G. versuta* had the largest average number of forms at the conclusion of the experiment.

The largest average number of hopper squares removed from the plants under any of the cages during the experiment was from those containing *L. pratensis*.

TABLE 5. SUMMARY SHOWING THE TOTAL DEAD FORMS REMOVED AND THE TOTAL LIVE FORMS PRESENT AND PLANT HEIGHTS AT THE BEGINNING AND CONCLUSION OF THE EXPERIMENT IN THE CHECK CAGES AND IN EACH OF THE CAGES CONTAINING SPECIES OF MIRIDS AND OF HOMOPTEROUS INSECTS. EACH RECORD IS AN AVERAGE FROM 6 COTTON PLANTS. TALLULAH, LA., 1931

Species	Total live forms		Total dead forms removed		Plant height (inches)		
	Beginning (June 30)	Conclusion (Aug 4)	Hopper squares	Naturally shed	Beginning (June 30)	Conclusion (Aug. 4)	Increase in height
Check	1.9	57.1	0	2.3	8.9	48.0	39.1
Lygus pratensis	2.0	1.2	28.3	1.5	10.5	30.7	20.2
Adelphocoris rapidus	2.0	8.5	24.4	3.4	8.5	42.0	33.5
Psallus seriatus	1.2	23.4	20.1	2.8	8.9	43.0	34.1
Homalodisca triquetra	2.7	58.4	0	3.1	10.0	37.9	29.9
Oncometopia undata	2.3	60.7	0	1.8	9.2	42.5	33.3
Graphocephala versuta	2.3	67.5	0	2.2	9.5	46.4	36.9
Stictocephala festina	2.7	41.9	5.7	4.5	9.8	34.0	24.2

The average increase in the height of the plants in the different cages during the experiment ranged from 39.1 inches in the check cages down to 20.2 inches in those containing *L. pratensis*.

The cage experiments of 1929 and 1930 with the same species of insects had given essentially the same results as those reported for the experiments of 1931.

Table 6 gives a brief summary of the results of the experiments of 1930. It will be noted that there was more natural shedding in each cage in 1930 than in 1931. This would be expected, as the plants of the

1930 series were further advanced when the experiment started than were those of 1931 (average number of live forms in 1930 was 13.8; in 1931, 2.1), and the plants were more mature in 1930 at the conclusion of the experiment. There was more natural shedding from the plants containing a full crop of fruit (check cages and cages containing homopterous insects) than from the plants exposed to mirids, where a certain amount of the fruit was continually being stripped from the plants by the insects. In 1930 the average number of naturally shed forms per plant in the cages containing the homopterous species was 14.0; in the check cages, 13.8; and in the cages containing the mirids, 8.4. At the conclusion of the experiment the average number of live forms per plant in the cages containing the homopterous insects was 69.8; in the check, 70.7; and in the mirid cages, 29.4.

TABLE 6. SUMMARY SHOWING THE TOTAL DEAD FORMS REMOVED, THE TOTAL AND INCREASES IN LIVE FORMS PRESENT, AND PLANT HEIGHTS AT THE BEGINNING AND CONCLUSION OF THE EXPERIMENT IN CHECK CAGES AND THOSE CONTAINING THREE SPECIES OF MIRIDS AND FOUR SPECIES OF HOMOPTEROUS INSECTS. AVERAGE OF 6 COTTON PLANTS. TALLULAH, LA., 1930

	Live forms			Shed forms		Plant height (inches)		
Species	Beginning (July 7–8)	Conclusion (Aug. 6)	Increase	Hopper squares	Naturally shed	Beginning (July 7–8)	Conclusion (Aug. 6)	Increase
Check	8.9	70.7	61.8	0	13.8	21.0	51.5	30.5
Lygus pratensis	14.9	24.2	9.3	49.5	6.8	18.5	35.7	17.2
Adelphocoris rapidus	9.7	24.9	15.2	41.6	6.6	18.0	44.2	26.2
Psallus seriatus	9.4	39.0	29.6	24.0	11.7	22.5	54.4	31.9
Homalodisca triquetra	18.7	78.7	60.0	0	14.2	20.7	45.2	24.5
Oncometopia undata*	16.3	58.6	42.3	0	15.0	18.7	43.0	24.3
Graphocephala versuta	16.0	66.2	50.2	0	15.2	17.2	46.4	29.2
Stictocephala festina	18.2	70.0	51.8	10.0	12.0	17.2	38.7	21.5

*Average of 3 plants.

A brief summary of the results of the three years of cage experiments with the four species of homopterous insects as compared with the three species of mirids follows.

Psallus seriatus produced typical "hopper damage." (See Plate 43, C.) Numerous small squares or "hopper squares" were shed as a result of the feeding of this insect on the buds or in the terminals of the main stem and branches, thereby materially reducing the number of live forms that would normally have been present on the plants; and feeding punctures caused a great number of lesions to appear on the main stems, branches, and leaf petioles and caused mutilation of the leaves. There was very

little difference in the height of the plants exposed to this insect as compared with the check plants.

Adelphocoris rapidus produced the same typical "hopper damage" as that described above for *P. seriatus*. (See Plate 43, A.) The damage was noticeably more severe in the cages exposed to this insect than in the *P. seriatus* cages. This was due to the fact that at times the infestation of *P. seriatus* dropped below normal, and that, per individual, *A. rapidus* is more injurious than *P. seriatus*.

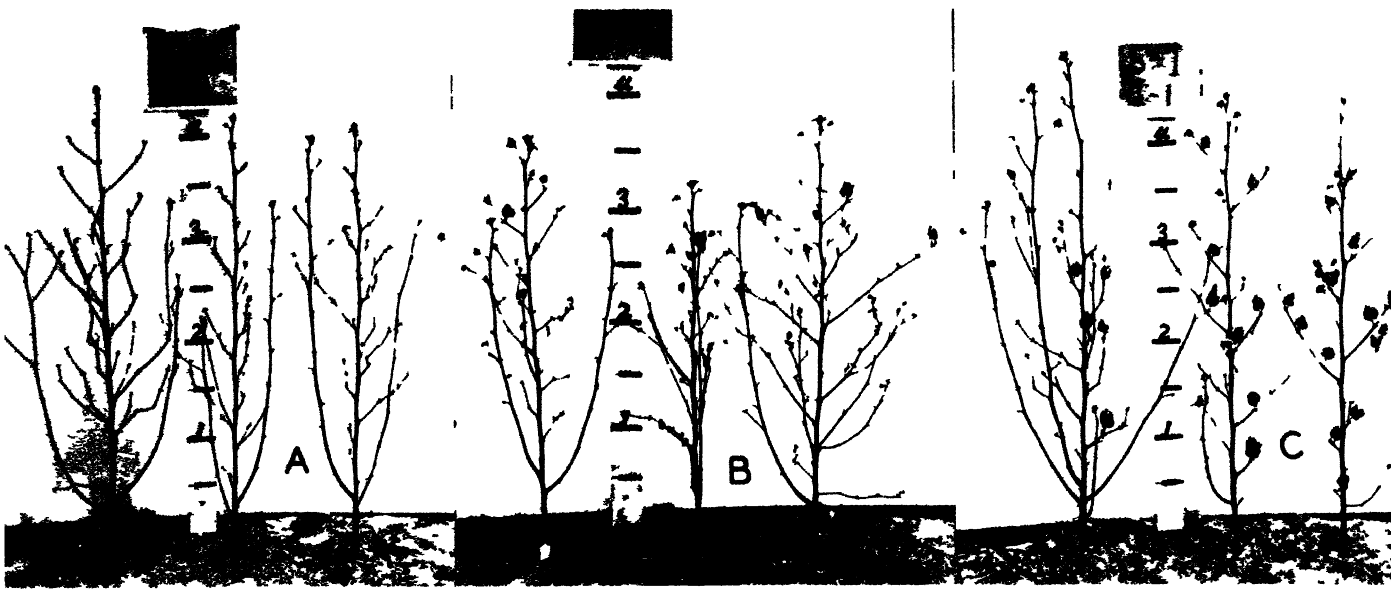
Lygus pratensis also caused injury similar to that produced by *P. seriatus* and *A. rapidus*. In addition, the plants exposed to this insect had a general "bushy" appearance, the growth in height of the plants being considerably retarded; there was also an excess of foliage and erratic branching. (See Plate 43, B.)

The cotton plants exposed to *Homalodisca triquetra* fruited normally (See Plate 44, A.) There were no hopper squares removed from the plants. In some instances small lesions were caused by this insect, but they were few considering the number of food punctures made There was a slight retardation in the growth of the plants, as evidenced by the plant-height records. Observations on the feeding habit of this insect showed that it fed on the stems and petioles, practically never feeding on the fruit or in the terminal buds. In several of the cages a generation of nymphs was reared on the plants from eggs deposited by the adults that were introduced. In no instance were they observed to feed in the buds sufficiently to cause the blasting of small squares. The fact that this insect is capable of producing small lesions at the point of puncture shows that its feeding is probably slightly toxic although in no way comparable to that of the mirids.

Plants exposed to *Oncometopia undata* fruited normally and did not shed any hopper squares. (See Plate 44, B.) In fact, what has been said of *H. triquetra* applies also to this insect with the exception that *O. undata* did not retard the growth of the plants quite so much as did *H. triquetra*.

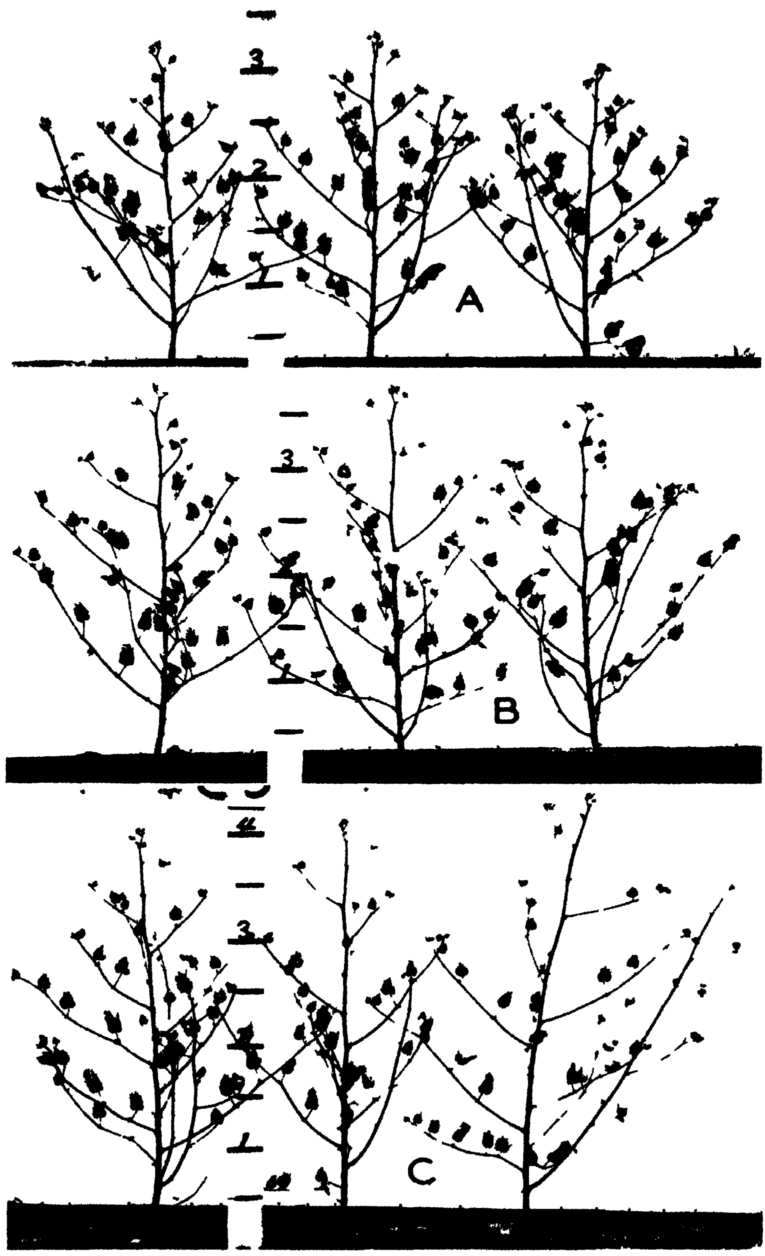
The tests conducted with *Graphocephala versuta* showed no evident damage to the cotton plant either in loss of fruit or abnormality of growth. (See Plate 44, C.)

The feeding punctures of *Stictocephala festina* are probably more toxic than those of any of the other Homoptera experimented with. Its peculiar habit of making rings of feeding punctures around petioles and stems often causes an abnormal growth. The stems or petioles so fed around or "ringed" usually grow at an angle from this point or sometimes break entirely off. (See Plate 45, B.) This is the most serious



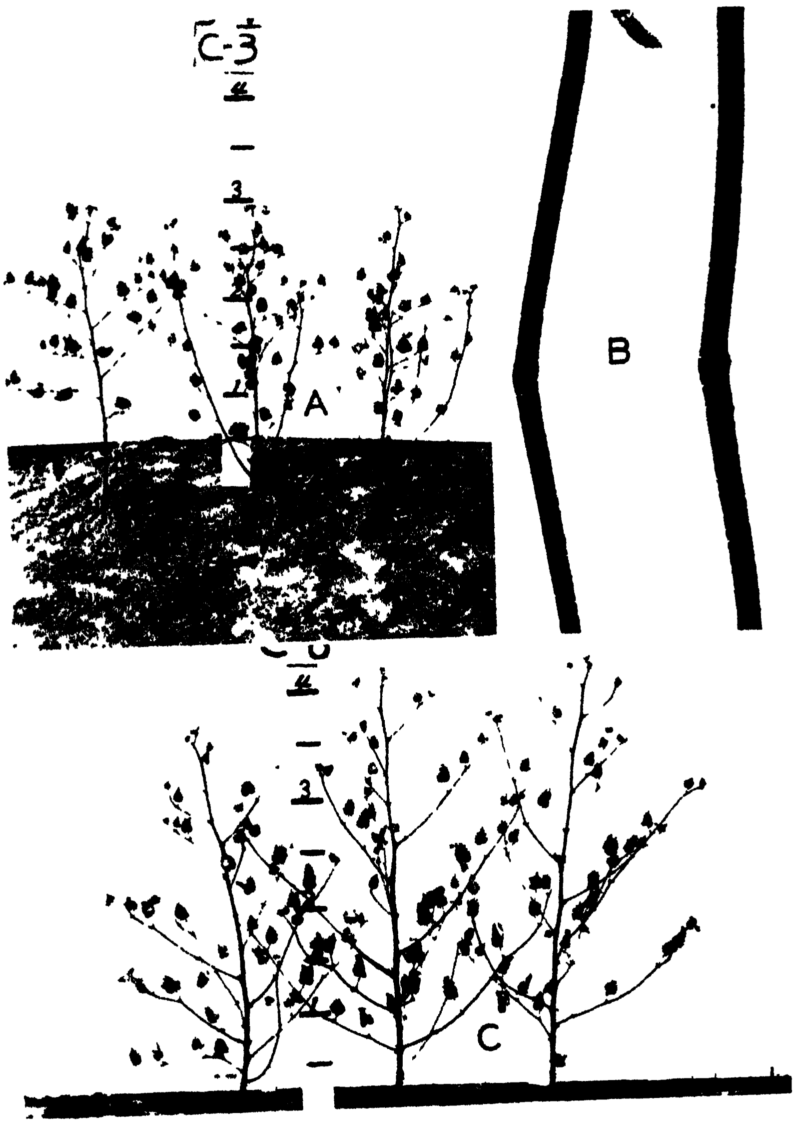
Cotton plants exposed to feeding by mirids for five weeks A Effect of feeding by *Adelphocoris rapidus* B by *Lygus pratensis* C by *Psallus seriatus* The leaves have been removed to show branching and lack of fruit Tallulah La, 1931

Plate 44



Cotton plants exposed to feeding by homopterous insects for five weeks. A, Effect of feeding by *Homolodisca triquetra;* B, by *Oncometopia undata,* C, by *Graphocephala versuta* The leaves have been removed to show branching and abundance of fruit. Tallulah. La.. 1931.

Plate 45



A. Cotton plants exposed to *Stictocephala festina* for five weeks (note a full crop of fruit); B. two cotton leaf petioles showing abnormal growth from the peculiar feeding habit of *S. festina* (note the swelling and change in direction of growth at the point where the insect fed around or "ringed" the petioles); C. cotton plants from which all insects have been excluded for five weeks (note a full crop of fruit). The leaves have been removed to show branching and fruit. Tallulah, La., 1931.

injury that this species causes to the cotton plant, although a few hopper squares were taken from each plant (average of 5.7 in 1931 and 10.0 in 1930). The plants exposed to this insect fruited normally, or at least the few hopper squares shed from the plants because of this insect were not enough to materially affect the final or total production of fruit. (See Plate 45, A.) Lesions were fairly common on the stems and petioles, and the growth of the plants was noticeably retarded.

For an illustration of normal growth and fruitage of cotton plants from which insects were excluded (checks) see Plate 45, C.

In the final analysis, the economic importance of insects that feed on the cotton plant is measured by their effect in keeping the plant from producing and maturing a full crop of cotton. The homopterous insects experimented with, namely, *Homalodisca triquetra*, *Oncometopia undata*, *Graphocephala versuta*, and *Stictocephala festina*, did not produce any material injury to the cotton plant, and the plants exposed to them were able to mature a full crop of cotton, whereas the mirids, *Psallus seriatus*, *Adelphocoris rapidus*, and *Lygus pratensis*, severely injured the cotton, in most instances causing the loss of almost all the fruit.

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DAMAGE TO THE COTTON PLANT CAUSED BY *MEGALOPSALLUS ATRIPLICIS* KNGT. AND OTHER SPECIES OF MIRIDAE

By R. L. McGarr, *Junior Entomologist, Division of Cotton Insects, U. S. Bureau of Entomology*

Abstract

Experiments have proved that *Megalopsallus atriplicis*, when allowed to feed on cotton, causes blasting or abortion of the young squares, and induces swellings and lesions on the stems and petioles and malformation of the leaves; and that *Psallus biguttulatus*, *P. pictipes*, *Reuteroscopus ornatus*, *Lygus cristatus*, *Megalopsallus latifrons*, and *Melanotrichus leviculus* cause swellings and lesions on the stems and petioles similar to those produced by *Psallus seriatus*.

Megalopsallus atriplicis Kngt., sometimes referred to as the "*Atriplex* hopper," is very similar to the cotton flea hopper, *Psallus seriatus* Reut.,

the similarity being so pronounced that some investigators have been at a loss to distinguish between the two. In fact, no distinction was made until 1927, when H. H. Knight separated the two species and described the new genus *Megalopsallus* (*3*). *M. atriplicis* occurs principally on the Atriplex plant, which is a perennial and commonly represented along the southeastern coast of Texas by the species *A. matamorensis*.

Experiments were conducted at Brownsville, Tex., in 1930, to determine primarily the feeding effect of *M atriplicis* on cotton. Six other species of Miridae, namely, *Psallus biguttulatus* Uhl., *P. pictipes* V. D , *Reuteroscopus ornatus* Reut., *Lygus cristatus* Dist., *Megalopsallus latifrons* Kngt., and *Melanotrichus leviculus* Kngt., in addition to *Psallus seriatus* (which was used as a check), were included in the experiments for comparative observations. All the tests were run on cotton protected by 4 by 4 by 4 foot cages covered with 16-mesh wire screen.

Three feeding methods were used, namely, the "24-hour," the "observed," and the "bag." As these methods are described in other papers (*1*), (*2*), only a brief discussion will be given here. In the first, or "24-hour" method, exposures were made for 24 hours with individual insects confined in small glass vials attached with adhesive tape. The limits of exposed areas were then marked with India ink to insure later identification, and after five daily examinations those petioles with no apparent swellings or lesions were sectioned and examined microscopically for internal injury. It is interesting to note that with this method external injury in the form of swellings or lesions was usually evident.

In the second, or "observed" method, attention was given to the length of the feeding period and character of the feeding. To induce feeding the insect was usually starved for a few hours prior to exposure and after five daily examinations all exposed areas were sectioned and the internal damage was studied microscopically.

In the third, or "bag" method, exposures were usually made for 72 hours with several hoppers introduced into each of several small muslin bags placed over the tips of the main stems and branches. The exposed areas were examined for five days after the removal of the insects, and blasted or otherwise damaged squares were especially noted.

The experiments with *Megalopsallus atriplicis* will be considered first. In 57 "24-hour" feeding tests with 21 adults on petioles, 47 instances of external injury and 6 of internal injury were observed, 2 tests showed neither external nor internal injury, and the results in 2 were doubtful. In 30 similar tests with 15 nymphs, 21 petioles with external injury and 3

with internal injury were observed, 5 showed neither external nor internal injury, and 1 was doubtful. Summarizing: In 87 "24-hour" tests with 36 adults and nymphs on petioles, 77 tests showed injury; 7, no injury; and 3 were doubtful. The percentages of petiole injury by adults was 93; by nymphs, 80; and both adults and nymphs, 88.5.

In 20 "24-hour" tests with 8 adults, each on a small square, 4 squares were blasted, whereas the others showed very little if any damage. Seven similar tests with 5 nymphs, each on a square, showed 3 blasted squares and but slight if any damage to the others.

In 18 "observed" feeding tests with 14 adults and 4 nymphs on petioles, 12 instances of internal and 3 of external injury were observed, and in the remaining 3 tests injury was doubtful.

The results of 43 "bag" feeding tests made chiefly on the tips of fruiting branches may be summarized as follows. Swellings or lesions were common on the stems, petioles, and midribs; 12 squares were blasted; 8 squares were doubtful as to the cause of shedding; and 21 squares showed external injury but not of sufficient severity to cause blasting or abortion. In these tests a total of 1,634 adults and nymphs were used, the maximum per bag being 108; the minimum, 22; and the average, 38.

Psallus seriatus is known to cause the blasting of young cotton squares, and to produce swellings or lesions on the stems and petioles and malformation of the leaves—a type of injury commonly called "hopper damage." Therefore, experiments with this species were run primarily as a check against the others. Twenty-seven "24-hour" feeding tests with 13 adults on petioles resulted in 21 instances of external injury and 6 of internal injury. Twelve similar tests with 7 nymphs resulted in external injury on 7 petioles and internal injury on 4, while 1 petiole showed neither external nor internal injury. Summarizing: A total of 39 "24-hour" tests with 20 adults and nymphs on petioles showed 38 instances of injury and only 1 instance of no injury The percentages of injury by *P. seriatus* adults was 100; by nymphs, 91.7; and by both adults and nymphs, 97.4.

Experiments with the remaining six species, which do not ordinarily occur on cotton, were made primarily for the purpose of determining whether they were capable, when allowed to feed on cotton, of producing injury. All of these experiments were of the "24-hour" feeding type and were conducted for the most part with adults on petioles.

Thirteen feeding tests with 10 adults of *Psallus biguttulatus* resulted in external injury to 5 petioles and internal injury to 8. Six similar tests with 4 nymphs showed 4 petioles with external injury and 1 with internal injury, while 1 showed no injury. The percentages of injury by

adults was 100; by nymphs, 83.3; and by both adults and nymphs, 94.7. With the remaining 5 species all of the "24-hour" feeding tests on petioles resulted in some injury, usually in the form of external swellings. The number of feeding tests with each species was as follows: *Psallus pictipes*, 21 with 10 adults; *Reuteroscopus ornatus*, 9 with 6 adults; *Lygus cristatus*, 13 with 10 adults; *Megalopsallus latifrons*, 9 with 4 adults; and *Melanotrichus leviculus*, 3 with 2 adults

It may also be well to mention that since there is no marked difference between the character of injury to petioles and stems, the younger petioles as a rule were used for study and for sectioning, as they contained less woody tissue than did the stems The results of all the "24-hour" feeding tests on petioles and stems are shown in Table 1.

TABLE 1. RESULTS OF "24-HOUR" FEEDING TESTS WITH *Megalopsallus atriplicis* AND OTHER SPECIES OF MIRIDAE ON COTTON PETIOLES AND STEMS

Species	Stage	Individuals	Tests	Petioles injured		Petiole injury with external lesions or swellings
		Number	*Number*	*Number*	*Per cent*	*Per cent*
Megalopsallus atriplicis	Adult	21	57	53	93 0	82.5
	Nymph	15	30	24	80.0	70 0
	Both	36	87	77	88 5	78 2
Psallus seriatus	Adult	13	27	27	100.0	77.8
	Nymph	7	12	11	91.7	58.3
	Both	20	39	38	97 4	71.8
Psallus biguttulatus	Adult	10	13	13	100.0	38.5
	Nymph	4	6	5	83.3	66.7
	Both	14	19	18	94.7	47 4
Psallus pictipes .	Adult	10	21	21	100.0	90.5
Reuteroscopus ornatus	Adult	6	9	9	100.0	77.8
Lygus cristatus	Adult	10	13	13	100.0	38.5
Megalopsallus latifrons	Adult	4	9	9	100.0	88.9
Melanotrichus leviculus	Adult	2	3	3	100 0	100.0

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FACTORS INFLUENCING THE ACTIVITIES OF THE COTTON BOLLWORM MOTH (*HELIOTHIS OBSOLETA* FAB.)

By J. C. GAINES, *Entomologist, Texas Agricultural Experiment Station*[1]

ABSTRACT

Continued observations on the activities of the cotton bollworm moth show that the growth of the cotton as indicated by the plant height and fruiting are factors that influence the moth and egg population. The migratory habits, time of flight, and proportion of sexes are also discussed.

A preliminary report dealing with the activities of the cotton bollworm moth (*Heliothis obsoleta* Fab.) during the season of 1931 has been published (*1*). The purpose of this paper is to add some information to that given in the previous paper and to present observations that were recorded during the season of 1932.

Since the occurrence of "spotted" infestations of the bollworm makes it difficult to know when to apply control measures, it is thought that information concerning the factors that influence the moth and egg population is important. It has been shown (*3*) that there is no relation between the infestation of this insect in cotton and the proximity to corn and that nectar and honeydew are unimportant factors. During the season of 1931 there apparently was no relation between the large moth catch and the comparatively small number of eggs, which was probably due to the drifting, or migration, of moths from field to field while seeking cotton more desirable for oviposition.

The two-wheel-cart type of trap (*1*) was again used during the season of 1932 to obtain information on the migration and the abundance of moths in two fields of cotton. Fields showing contrast in the condition of growth were selected. In one field, designated as rank, the cotton grew faster and produced more fruit than in the field designated as small.

During the period from July 4 to August 22, 1932, 284 moths were captured in the trap from the two fields. Two hundred and nine of these moths were marked before release in such a way that the date of release could be ascertained if they were recaptured. Moth collections were made in two fields, which were about 1 mile apart, and in random cuts between the fields. No moths that had been marked were recaptured, probably owing to the small number that were marked and to the relatively small acreage on which the trap could be operated. Both male and female moths were carefully observed in the field during the

[1]In cooperation with the Bureau of Entomology, United States Department of Agriculture.

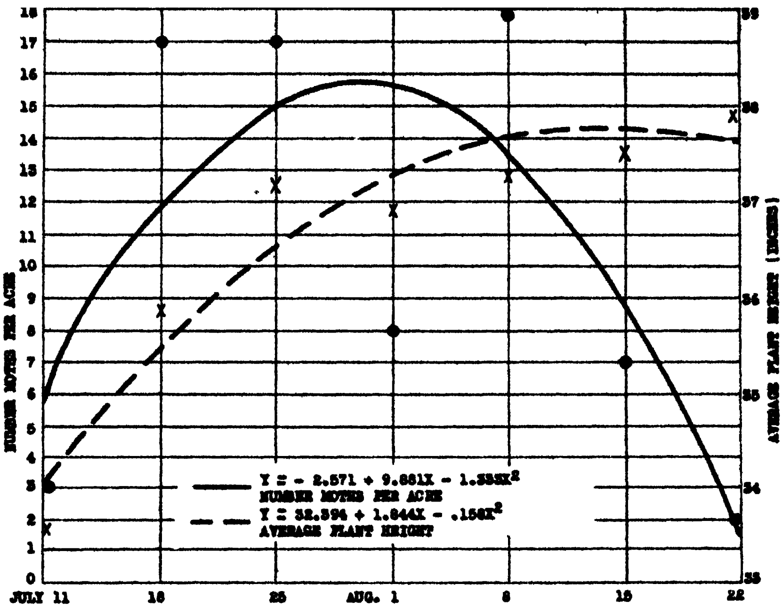

Fig. 71.—Parabolic curves showing the average moth catch and the average plant heights during the period from July 11 to August 22 in the field of rank cotton.

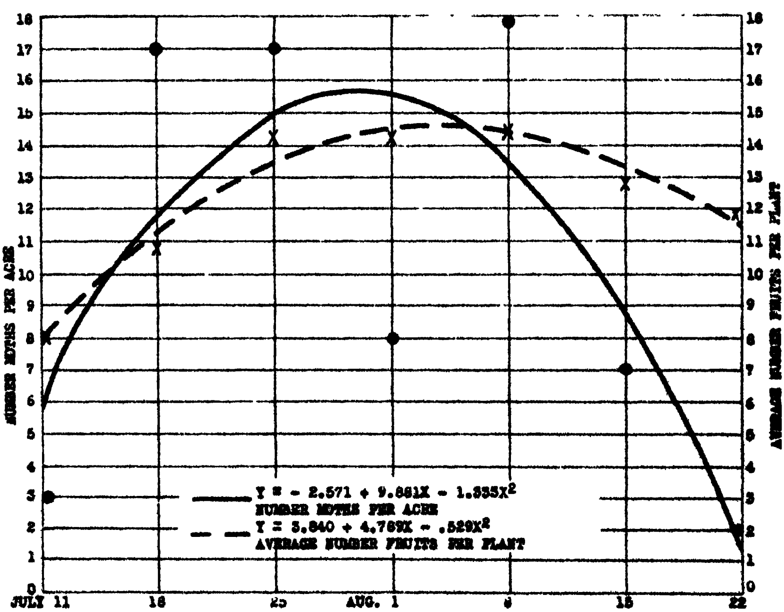

Fig. 72.—Parabolic curves showing the average moth catch and the average fruit per plant during the period from July 11 to August 22 in the field of rank cotton.

time the first generation was in the cotton. The moths rested during the day in secluded places on the cotton plant, the only movement being occasional crawling over the plant to places that afforded better protection from the sun. Moth activities began just at dusk and ceased about daylight. During the periods that the moths were active they flew from plant to plant feeding and ovipositing, sometimes flying as far

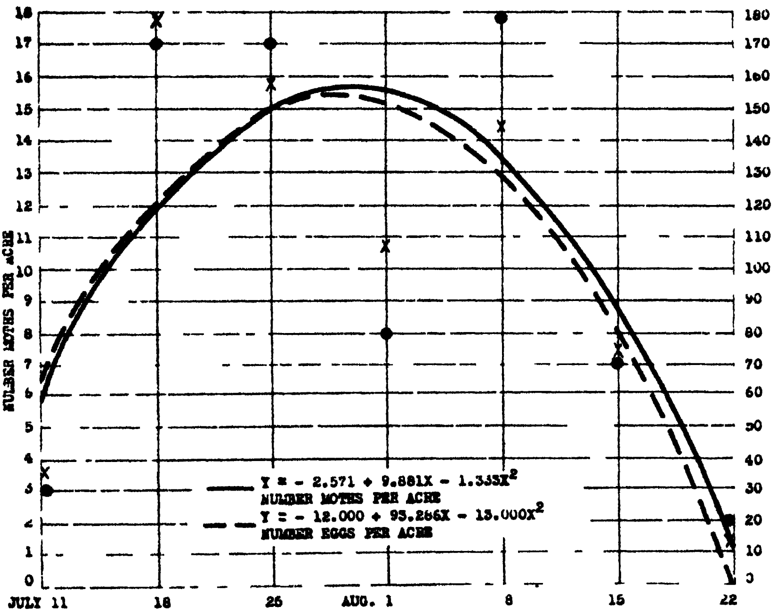

Fig. 73.—Parabolic curves showing the average moth catch and the average number eggs per acre during the period from July 11 to August 22 in the field of rank cotton.

as 100 yards or more in one flight. These observations indicate that the moths, during the active period, visit a large number of cotton plants and may travel quite a distance. Determinations of the moth catch during the entire season showed that the sexes were about equally divided, although the males were slightly in the majority. During the first week of each generation, however, there were about twice as many males as females.

In order to determine the relation between the growth of cotton, the number of fruits per plant (squares, bloom, and bolls), the moth population, and egg deposition, the cart type of trap was operated three times a week on 1 acre of small and 1 acre of rank cotton. The catch, or number of moths, was averaged for the week, and the growth of the cotton,

the number of fruits per plant, and the number of eggs per acre were recorded at weekly intervals. The data for both fields are presented in Table 1.

TABLE 1. RECORDS OF PLANT HEIGHTS, FRUIT, MOTHS, AND EGGS IN RANK AND SMALL COTTON

Seven-day period ended—1932	Average plant height Rank *Inches*	Small *Inches*	Average fruits per plant Rank *Number*	Small *Number*	Moths caught per acre* Rank *Number*	Small *Number*	Average eggs per acre Rank *Number*	Small *Number*
July 4 .	——	27.19	——	11.97	—	3		0
July 11 . .	33 66	29.25	8.03	12.66	3	5	36	19
July 18 .	35.80	28.91	10 92	9.89	17	12	180	26
July 25 . .	37.20	28.59	14.38	8.20	17	4	156	39
Aug. 1	36.91	28 23	14 30	6 06	8	1	108	0
Aug. 8	37.25	28.24	14.46	5.13	18	2	144	0
Aug. 15	37.54	———	12.95	——	7		72	—
Aug. 22	37.88	——	11 82	———	2		12	—

*Average of three collections.

From the data in this table it is seen that the cotton in the field designated as rank grew faster and over a longer period than that in the field designated as small. Unless there is a significant increase in the plant heights, it is said that no growth takes place. Many more moths were

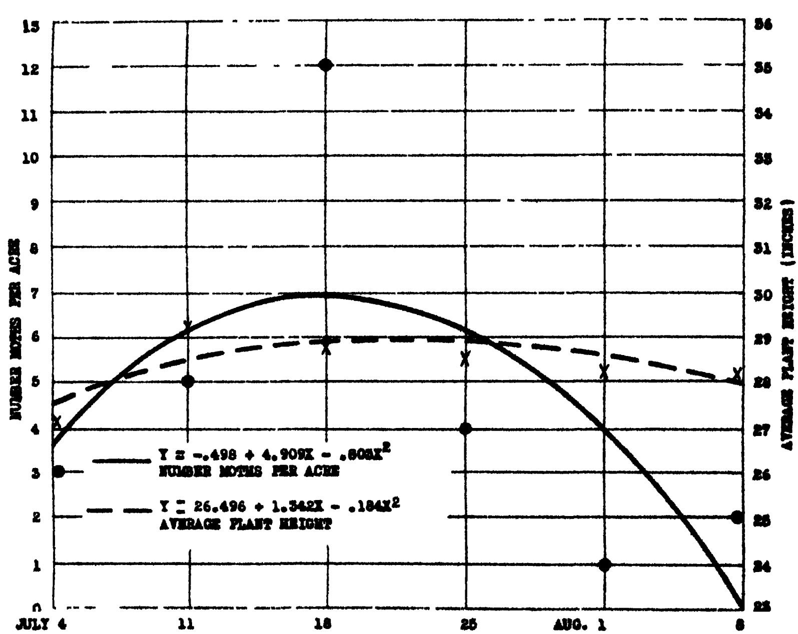

Fig. 74.—Parabolic curves showing the average moth catch and the average plant heights during the period from July 4 to August 8 in the field of small cotton

captured, more eggs were deposited, and more fruit was produced in the rank cotton than in the small cotton. It will also be noted that in both fields, after the cotton began to deteriorate, the number of moths and the number of eggs were considerably lower. This occurred in the field of small cotton about July 25, but in the field of rank cotton not until about August 15.

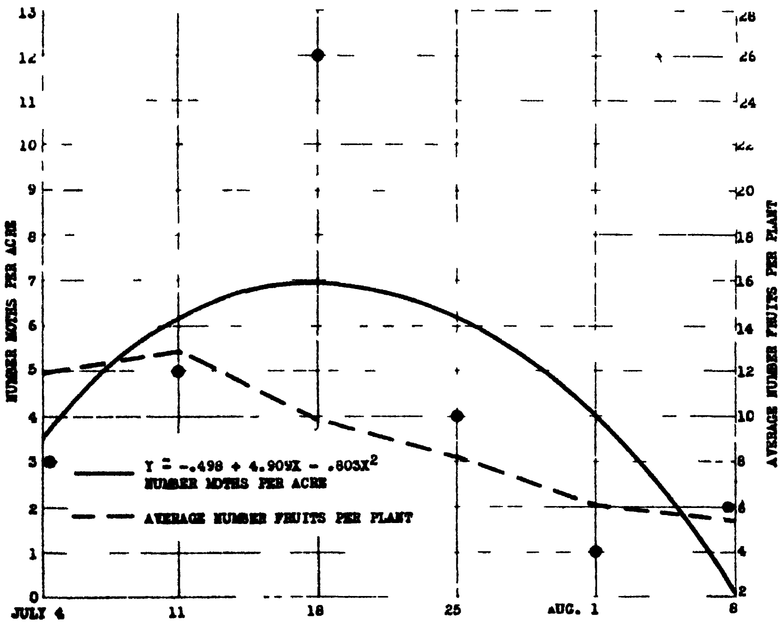

Fig. 75.—Parabolic curve showing the average moth catch and the average fruit per plant during the period from July 4 to August 8 in the field of small cotton.

For each of the factors plant height, fruit, eggs, and moth catch a curve, which is a second-degree parabola, has been fitted by the method of least squares (2). In each case, (Figs. 71 to 76), the equation for the curve is given. These curves show the trend for each variable during the period of time in which two generations of bollworm moths occurred in the cotton.

In the field of rank cotton, during the 7-day period ended August 8, the moth catch had begun to decrease, and the cotton had practically stopped growing (Fig. 71), had stopped fruiting (Fig. 72), and the average number of eggs had begun to decrease (Fig. 73). In the field of small cotton, however, these phenomena occurred during the 7-day period ended July 25 (Figs. 74, 75, and 76, respectively.)

During this season, when the moth population was low and all the moths were probably of local origin, there was a close association between the average plant heights, the number of fruits per plant, the average moth catch, and the average number of eggs per acre. At

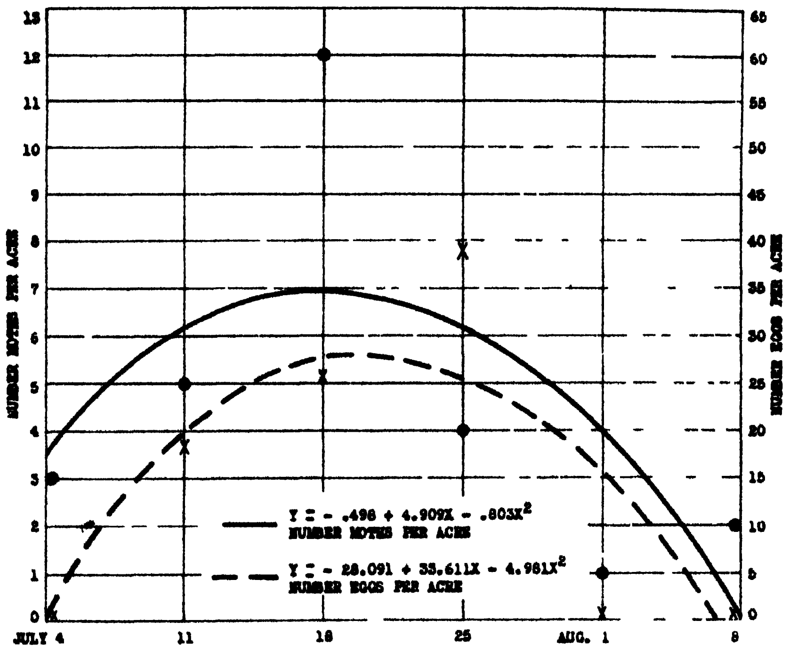

Fig. 76.—Parabolic curves showing the average moth catch and the average number of eggs per acre during the period from July 4 to August 8 in the field of small cotton.

the time the cotton stopped growing, as indicated by the plant height and fruiting, the moth and egg populations began to decrease in the fields of rank cotton and also in those of small cotton. The "spotted" infestations that occur every year are due to the rapid growing and fruiting of the cotton plants, which are factors that tend to increase the moth and egg populations.

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A STUDY OF THE COTTON FLEA HOPPER WITH SPECIAL REFERENCE TO THE SPRING EMERGENCE, DISPERSAL, AND POPULATION

By J. C. Gaines, *Entomologist, Texas Agricultural Experiment Station*

Abstract

The population of the cotton flea hopper, *Psallus seriatus* (Reut.), is increased by rainfall which produces a rapid growth of the host plants. Early fall rains which promote the growth of fall weeds are influential in determining the number of insects that emerge the following spring. Time of spring emergence and dispersal are factors that influence the population in cotton.

The cotton flea hopper, *Psallus seriatus* (Reut.), like many other insects, has rather definite periods during the year when it transfers from one host to another. Early in the season the insects migrate from the weed fields and are disseminated in cotton. Later, usually during July or August, the insects leave cotton and migrate to goatweed fields where the greater portion of eggs are deposited and remain overwinter. The fact that in a given year cotton is heavily infested with flea hoppers in some localities and not in others and the fact that the localities in which cotton was heavily infested one year but may not be infested the next have given rise to considerable speculation as to the cause of these conditions.

The present paper summarizes the results of three years' observations, 1930, 1931, and 1932, in the vicinity of College Station, Texas. This phase of the cotton flea hopper problem deals with the various factors that affect the population or the number of insects that develop and cause injury to cotton.

The emergence or the number of flea hoppers hatching in the spring was obtained by gathering 100 goatweeds (*Croton capitatus*) from each of several selected fields and placing them in cages about February 1, or before the overwintering eggs begin to hatch. The cages are wooden frames, constructed of 1″ x 4″ material and measure 2′x 2′ x 3′. The sides and top are covered with black percale with a series of 28 vials inserted around the top and halfway down one edge on each side. The light which comes through these vials serves to attract the young insects as they hatch from the weeds. The flea hoppers were taken out of these vials daily during the spring and the numbers recorded.

To determine when cotton flea hoppers were actually flying, a series of traps (Fig. 77) was set up in both cotton and goatweed fields. Each trap was made by tacking a piece of ordinary screen wire to a 5′ x 3′ frame, constructed of 1″ x 2″ material. The ends of two of these frames were

nailed together and also to three posts placed in the ground in triangular arrangement, the two frames forming a right angle with the bottom edge about three feet above the ground The wire was coated at regular intervals throughout the year with a sticky tree-banding preparation These traps were visited at least every two days and, when possible, every day, the cotton flea hoppers were removed and the number recorded

Fig 77 --Standard type of trap used to capture cotton flea hoppers

The population records were obtained by making 100 sweeps with a 16" diameter insect net, and the number of adult cotton flea hoppers was recorded These records were made at weekly intervals in both the goatweed and the cotton fields from early spring until late fall A minimum of 20 adult cotton flea hoppers per 100 sweeps is considered as being sufficient to cause injury to cotton

Dispersal and Population in 1930 —Sixteen screen traps (Fig 77) were located in cotton fields during the season of 1930 It was found that the dispersal and population were greater in some fields than in others, but the time of dispersal was about the same in all the fields Therefore the data have been summarized and are discussed accordingly.

The screen traps were set up in July after the spring migration had taken place The first period in which the trap catch was high occurred between July 15 and August 15 This period occurred just after the population in cotton had reached its maximum. (Table 1) Following this and until about the middle of September, a light, general movement was noted which was indicated by the trap catches Then another period began in which the catch was high and lasted until about the middle of October, during which time the flea hopper population was high in goatweeds (Table 1) Apparently this fall activity was due to the insects flying about in search of a desirable location to oviposit.

TABLE 1. RECORDS OF THE NUMBER OF ADULT COTTON FLEA HOPPERS PER 100 SWEEPS IN COTTON AND GOATWEEDS IN 1930

	July 16	July 31	Aug. 12	Aug. 28	Sept. 8	Sept. 26	Oct. 3	Oct. 10	Oct. 17
Adults per 100 sweeps in cotton*	8	11	1	0	0	0	0	0	0
Adults per 100 sweeps in goatweeds*	—	—	—	—	—	986	1,585	288	60

*Average of 16 fields of cotton and 3 fields of goatweeds.

During the period from July 12 to November 15, 1930, the average weekly maximum temperature varied from 68° to 102° F., while two distinct periods occurred when the catch was high on the traps. The correlation coefficient between the daily maximum temperature and the daily trap catch was $.196 \pm .057$, which indicates that the correlation between these two variables is barely significant. Temperature seems to be an unimportant factor on the dispersal of the cotton flea hopper since there were days on which the trap catch was low and the temperature was low and other days on which the trap catch was low and the temperature was high.

After analyzing the data it was found that there were days between July 12 and November 15 when the humidity was low and the trap catch was low, and there were days when the humidity was high and the trap catch was low The correlation coefficient between the daily minimum relative humidity and the daily trap catch is $-.073 \pm .059$. This insignificant correlation coefficient and a comparison of the data representing the two variables indicate that minimum relative humidity was also an unimportant factor on the flea hopper dispersal

Rainfall seemed to be an important factor influencing the population in both cotton and goatweeds During June, July, and August the rainfall was below normal, causing the cotton to stop growing, and the flea hopper population decreased. During September and October the rainfall was above normal, causing the goatweeds to grow rapidly, affording an ideal place for the flea hoppers to feed and breed, and the population increased to high numbers. (Table 1.)

EMERGENCE, DISPERSAL, AND POPULATION IN 1931.—Cotton on black land sections of Texas, on which goatweeds (*Croton capitatus*) do not grow, and which are from 10 to 25 miles from fields of goatweeds, become heavily infested with flea hoppers in the early spring practically every year. Since goatweed is the principal host for the flea hopper to deposit eggs that overwinter, it was deemed advisable to determine the distance at which a goatweed field would influence the spring population of flea hoppers in cotton. A desirable location was found in the Brazos

River Bottoms, Burleson county, Texas, where a section of level bottom land about four miles wide and principally planted to cotton, bordered a goatweed field several miles in length on the south side. Screen traps were located in this strip of goatweeds and extended northward in the cotton at one-eighth, one-fourth, one-half, three-fourths, and one and one-fourth miles from goatweed fields.

The first adult flea hopper was captured on the trap located one and one-fourth miles from goatweeds on April 14, before the cotton had been planted. There was no significant difference between the catch on any of the traps or the population in the different cotton fields. From these data, it is evident that in this case the flea hopper population in cotton was not affected by being in close proximity to goatweeds.

Since there was little difference in the time of dispersal as indicated by the trap catches at the different locations, the data have been summarized and are discussed accordingly for both cotton and goatweeds.

It will be noted that the 1930 fall flea hopper population in goatweeds was high during the latter part of September and October. (Table 1.) The average number of insects that hatched during the spring of 1931 from 100 of these goatweeds was also fairly high. (Table 2.) About 94 per cent of the insects hatched during March and April, or before cotton was up to a stand. This condition caused a large number of the young insects to die early in the season in the event they were disseminated by wind from the weed fields to cotton fields. A small number of early-hatched nymphs matured and was flying through the cotton fields by April 14. Due to the small number of insects that could survive the early temperatures and transfer to cotton from the weed fields, the population was slow in developing.

TABLE 2. THE AVERAGE NUMBER OF COTTON FLEA HOPPER NYMPHS THAT EMERGED FROM 100 GOATWEEDS

1931	March	April	May	Total
Number of nymphs that emerged from 100 goatweeds*	2,326	1,666	241	4,233
Per cent emerged	54.94	39.36	5.70	100.00

*Taken from the same fields in which sweeping records were made the previous fall.

The curves showing the average weekly catch on the traps and the population in both goatweeds and cotton are shown in Figures 78 and 79, respectively. It will be noted that a general high peak of catch occurred in cotton during May and June. The insects increased in numbers in the weed fields on miscellaneous weeds, including horsemint (*Monarda* spp.), until about June 8 when the population decreased in the weed fields and increased in cotton. A high peak of catch was recorded

on the traps located in the weed fields about the middle of June, or about the time the flea hoppers transferred from the weeds to cotton. Another small peak of catch occurred on the traps in both cotton and

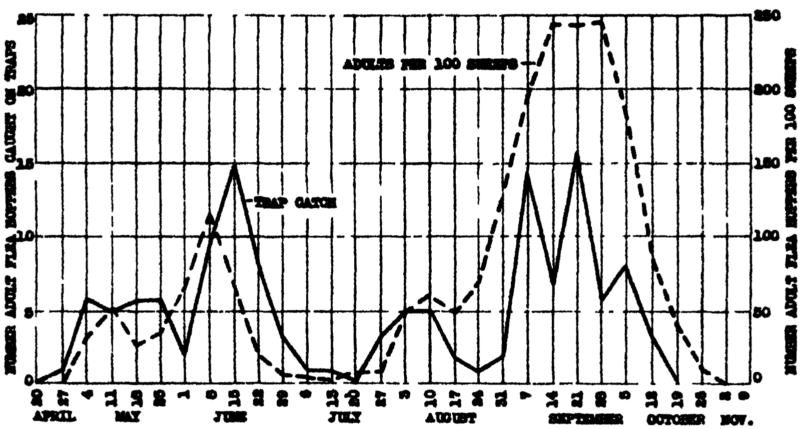

Fig. 78.—Number of cotton flea hoppers captured on two traps and the average number adult flea hoppers per 100 sweeps in the two fields of goatweeds around each trap in 1931.

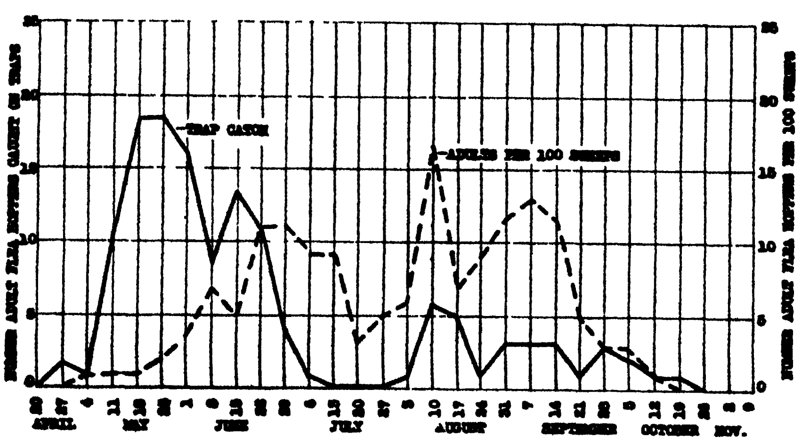

Fig. 79.—Number of cotton flea hoppers captured on seven traps and the average number adult flea hoppers per 100 sweeps in the seven cotton fields around each trap in 1931.

goatweeds about the time the population again increased in cotton and in goatweeds. A general high peak of catch occurred on the traps located in goatweed fields during September and October, or when the insect population was high in goatweeds. Due to late-planted cotton in two

of the fields, a few of the insects remained in the cotton until late in the season.

One trap was set up with the bottom edge six feet from the ground in the same field in which a standard trap was located which had the bottom edge three feet from the ground. This trap was located to determine at what altitude the largest number of insects was flying. Since the catch on these traps was practically the same except during the early part of the season, the difference in catch will be discussed for April and May only.

The catch was higher on the high trap than on the standard trap. (Table 3.) About 83 per cent more insects were captured on the high trap during April and May than were captured on the standard trap. Apparently the insects were flying high and migrating in from long distances during this early dispersal period.

TABLE 3. RECORDS OF THE NUMBER OF ADULT COTTON FLEA HOPPERS CAPTURED ON A HIGH TRAP COMPARED WITH A STANDARD TRAP CATCH IN THE SAME FIELD

Date 1931	Bottom edge of trap three feet from ground* Number adults captured	Bottom edge of trap six feet from ground Number adults captured
April	2	39
May	74	100
Total	76	139

*Standard Trap.

The recorded rainfall was below normal during every month from May to October, inclusive. This factor caused a slow growth in both cotton and goatweeds, and the flea hoppers did not increase to large numbers in either. The flea hopper population was much lower in the goatweeds during the fall of 1931 than it was in 1930, when much more rain was recorded during September and October.

EMERGENCE, DISPERSAL, AND POPULATION IN 1932 — Three traps were set up in cotton fields during the latter part of March, and later on, June 15, a trap was set up in a cotton field where an infestation was developing. Three traps were also set up in goatweed fields in March. The average catch for these traps is discussed since the time of dispersal was about the same at each location. Since the high screen trap in 1931 indicated that the insects were flying high at certain periods of the year, a tall trap was set up in a cotton field during 1932. (Fig. 80.) This trap was made on the same principle as the standard trap but extended into the air 25 feet with the wings only 3 feet wide.

The flea hopper population was considerably lower in the goatweeds during the fall of 1931 than in 1930, and the spring emergence from the weeds was lower in 1932 than in 1931. (Table 4.) The fall flea hopper

population in goatweeds is an important factor in determining the number of nymphs that hatch in the spring. The time and the number of nymphs that hatch are factors that help to determine the extent of injury that may occur in cotton. In the spring of 1932 over 16 per cent of the nymphs hatched during May after cotton was up to a stand and there was an abundance of weeds and seedling cotton in which the insects could develop. A few early-hatched nymphs matured and were flying through the fields by April 8.

The curves representing the average weekly catch on the traps and the population in both goat weeds and cotton are shown in Figures 81 and 82, respectively. A general movement, as indicated by the trap catches, was noticeable in the cotton early in the season. The fact that there was very little horsemint present and that there was no peak in the insect population of the weeds early in the spring probably accounts for there not

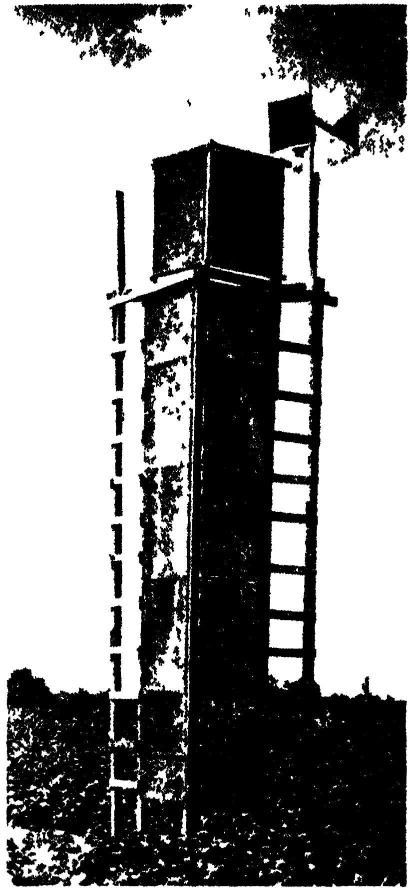

Fig. 80. Tall trap used to capture cotton flea hoppers.

Table 4. Records of the 1931 Fall Cotton Flea Hopper Population and the 1932 Spring Emergence from Goatweeds

Date 1931	Number adults per 100 sweeps in goatweeds	Date 1932	Number nymphs that emerged from 100 goat weeds*	Per cent emerged
Sept. 11	199	March	1045	59.31
Sept. 18	242	April	424	24.07
Sept. 25	239	May	293	16.62
Oct. 2	243	Total	1,762	100.00
Oct. 9	178			
Oct. 16	85			
Oct. 23	40			
Oct. 30	12			

*Taken from the same fields in which the sweeping records were made the previous fall.

being a higher peak of catch on the traps during this early spring period. Another and a much higher peak of catch occurred on the traps in the cotton during July and the first half of August, at which time the

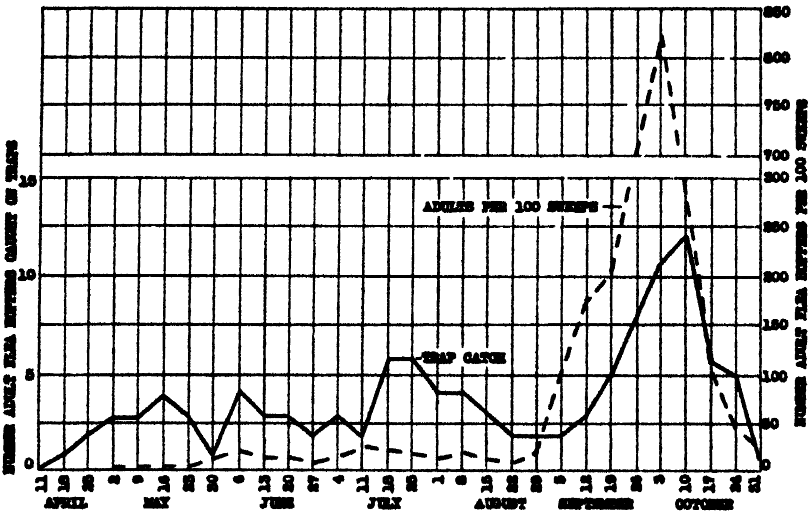

Fig. 81.—Number of cotton flea hoppers captured on three traps and the average number adult flea hoppers per 100 sweeps in the three goatweed fields around each trap in 1932

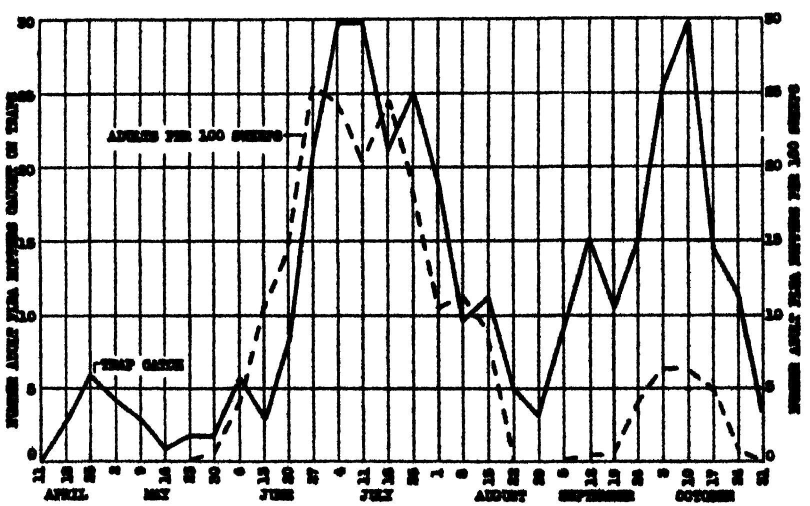

Fig. 82.—Number of cotton flea hoppers captured on five traps and the average number adult flea hoppers per 100 sweeps in the five cotton fields around each trap in 1932.

population was high, causing severe injury to cotton. A peak of catch also occurred on the traps in the goatweed fields during July and the first half of August which indicates that the transfer from cotton to goatweeds occurred about this time. High peaks of catch occurred in both cotton and goatweed fields during September and October at which time the population was high in goatweeds and in some cotton fields. The trap catches indicate the time that the flea hoppers transfer from one crop to another and also indicate to some extent the abundance of insects that are in the fields.

The catch on the portion of the tall trap corresponding to the same altitude on the high trap used in 1931 was not consistent, probably due to the different type of trap that was used in 1932. The high trap used in 1931 was only 9 feet high with free circulation of air around the 3′ x 5′ trap area, while the tall trap used in 1932 was a continuous trap area from 2′ to 20′ in height. However, the trap area from 21′ to 25′ did have free circulation of air and is comparable to the catch on the bottom portion of the trap. About 10 times as many adult flea hoppers were captured on the portion of the trap from 21′ to 25′ from the ground as were captured on the portion of the trap from 2′ to 6′ from the ground during April and May. The catch seemed to be about the same at the different altitudes during the summer months but was considerably higher on the highest portion of the trap during October. This indicates that the adults fly high and spread over long distances during these two dispersal periods.

Practically a normal rainfall was recorded during the spring which caused the cotton to grow rapidly during June and the first half of July. The cotton stopped growing early in August on account of insufficient moisture, and the flea hopper population decreased. Excessive rains during September caused the goatweeds to start growing, and the population of this insect increased rapidly during the latter part of September and the first week in October. These early fall rains caused the flea hopper population to be much higher in goatweeds during the fall of 1932 than in the fall of 1931 when the rainfall was below normal and were similar to the fall rains of 1930, which also caused a large increase in the number of flea hoppers.

SUGARCANE BORER EFFECT UPON VALUE OF SEED CANE

A Preliminary Report

By W. E. HINDS, *Entomologist* and B. A. OSTERBERGER, *Assistant Entomologist*
Louisiana Experiment Station

ABSTRACT

During recent years especially, leaders in sugarcane borer control investigations have strongly advocated the utilization of seed stock which is as free from borer infestation as it is possible to secure. However, no actual studies measuring the effects of borer infestation in seed cane upon the resulting stands and yields during the following season had been made until 1928 1929. At this time a plantation field test was made with POJ. 213 cane, including three acres or more in each area, and using practically borer free seed in one field and all lightly infested seed cane in the other field The following August there was found to be a decrease amounting to approximately 14% in the number of canes per 1000 row-feet. There was an excess amounting to 13.5% in the unoccupied ground or "skips" included in excess of three feet along the rows. At harvest time the lightly infested seed field averaged 9% less in weight of cane, or approximately three tons per acre less yield than in the borer free seed field.

In 1931–1932 six varieties of cane were tested in a very detailed and accurate way at the Louisiana Sugar Experiment Station. Seed of each variety was selected for three classes of infestation, representing (1) practically borer "free," as based upon evidence of borer burrows in the cane, (2) "light" or "medium" infestation and (3) "heavy" infestation. Before the cane was covered, a close examination was made to determine the condition of eyes, the number of eyes planted, borer burrows, emergence holes, etc., in each plat Replicated plats of 50 feet were used and the cane was planted single stalk and butt to tip. The rate of seed per acre required on this basis ranged from 1837 pounds with longest jointed, most slender type of cane, to 3240 pounds with the shortest jointed, heaviest stalks. The winter was exceedingly mild with no killing frost until March 6, 1932. In February there was a very evident decrease in germination or retardation in germination in the more heavily infested plats as compared with the borer free seed plats. There was a consistent trend in the direction of increase in "skips" (in this case taken as the excess above 18 inches space between stools) as infestation in the seed increased, and a correlating decrease in the number and total weight of millable stalks produced. The loss in yield, as computed

from the plat to the per-acre basis, showed a loss ranging up to 8.5 tons per acre with the most susceptible variety. The more vigorous growing types of cane suffered less than those of medium-vigorous growth, but in all groups it is very evident that the increase of borer infestation in seed cane produces an important loss in following yields. The average loss in three varieties of medium vigorous growth was 17.5%, or over 4 tons per acre. With the three varieties of more vigorous growth the loss amounted to practically 2½ tons, or an average of 7.1% of the yield secured in the borer free plats of the same varieties.

SUGARCANE BEETLE INJURY TO GREENHOUSE ROSES

By Clay Lyle, *Entomologist, State College, Miss.*

Serious injury to greenhouse roses by adults of the sugar cane beetle or rough-headed corn stalk-beetle, *Euetheola rugiceps*, was observed at Columbus, Mississippi, the first week in September, 1932. Apparently the time of greatest damage was three or four weeks earlier as most of the beetles had disappeared when the injury was discovered. About 12,000 roses were in the greenhouse; and from sample counts, it was evident that about 67% of the plants had been attacked. All of the injury was of the same type, the bark having been gnawed just below the soil surface. Some plants were almost cut in two. When the injury was noticed, callouses were already forming, and many of the plants eventually recovered.

This unusual injury in greenhouses apparently resulted from filling the benches with soil from a nearby pasture in June, at which time the beetles were in the egg or a very small larval stage and escaped notice. The soil was taken from a strip along a small ditch through a pasture which was thickly sodded with various grasses Although this is the first case of this kind noticed, nursery inspectors may find it advisable to caution greenhouse operators about the localities from which they select soil for filling benches, since heavy loss may occur in a single instance such as the one reported here.

A METHOD OF AVOIDING THE DESTRUCTION OF TRICHOGRAMMA IN SUGARCANE FIELDS

By T. E. Holloway, *Bureau of Entomology, U. S. Department of Agriculture*

Abstract

Attention is called to experiments started twenty years ago on the conservation of sugarcane "trash" as a method of avoiding the destruction of Trichogramma. Bacteriologists and others now find that the incorporation of the trash in the soil is desirable.

We hear much nowadays of the breeding and release of the parasite *Trichogramma minutum* Riley, which is a common and widely distributed parasite of the eggs of the sugarcane borer (*Diatraea saccharalis* Fab.) and of many other insects. The wholesale destruction of this beneficial insect by the burning of the "trash" or dead leaves left on the sugarcane fields after harvest is to be deplored as a waste.

The sugarcane plant is plentifully supplied with leaves, which are cut off and left on the fields when the cane is cut and hauled to the mill. At the time of harvest Trichogramma is naturally present in large numbers in nearly every field. No one knows just how or where it hibernates in the Louisiana cane fields, but it is believed to be a weak flier, and we can hardly suppose that it flies out of the fields when cold weather commences. Why should it? The low temperatures would induce inactivity and tend to prevent flying, and the parasite would not need to seek other hibernation quarters when they are present in abundance in the masses of leaves left on the fields.

The universal practice on sugar plantations, however, has been to burn over the fields as soon as possible. It was once thought that this would destroy the larvae of the sugarcane borer, but it is now known that the borers are safe in their tunnels in stubble cane, planted cane, coarse grasses, and juicy scraps of cane. The fires run over the fields quickly, consuming the covering of leaves but leaving the borers in the canes unharmed.

Of course, the borers contained in the scraps of cane which are left on the field can be killed. With infinite pains the scraps can be collected and destroyed. But this is never done, at least on real sugar plantations by plantation people.

Trichogramma minutum was found to be a parasite of the sugarcane borer in Louisiana in 1912, and in the same year the writer (*1*) suggested that experiments in natural control be initiated by preserving the trash from burning in an attempt to avoid destroying its content of parasites. These experiments were followed by similar tests over a period of a good many years. They have been fully reported in sugar

journals and Government bulletins (*2, 3, 4, 5, 6*). It was found that the non-burning of cane trash gave good results where it was carried out over a whole plantation. Even where adopted on a small scale it probably preserved many parasites, but the results in lessened damage from the borer thus obtained were not usually apparent owing, doubtless, to the flight from field to field of both borer moths and parasites. The criterion of the success of these experiments was not in reduced borer population or increase in parasite population, but in the actual lessened damage to the sugarcane where large areas were left unburned.[1]

As the experiments previously referred to are recorded in the literature it is unnecessary to mention them further, but some of our results have been favorably quoted by A. D. Imms, of the Rothamsted Experimental Station, in his lately published book, "Recent Advances in Entomology," (*7, p. 352*). In this he reprints our table showing that in a season when the loss due to the borer was 13 per cent at the Audubon Park Experiment Station, where trash was not burned, it was 30 per cent over the State, with similar results for other years.

While the entomology of the non-burning of trash was worked out years ago, it was not until rather recently that the other phases of the subject were investigated. The incorporation of cane trash with the soil has now been studied by bacteriologists and agronomists, all of whom report favorably on this practice.

Owen and Denson (*8*), bacteriologists of the Louisiana Experiment Station, conclude, "The fact that field experiments over a period of several years at this station have shown no decrease in crop yields from the practice of turning under cane trash it would appear that the nitrate nitrogen immobilized by the presence of the organic matter is in excess of the immediate requirements of the growing crop. This would make the practice of turning under trash consistent with the necessity of conserving the surplus available nitrogen in the soil."

Sturgis (*9*), also of the Louisiana Experiment Station, writes, "By the

[1]In some countries where the value of this practice of not burning trash has been shown, by work similar to that done in Louisiana, the conservation of trash has been widely adopted. Almost everywhere in Puerto Rico that ratoon cane is grown, fields with the trash lined in alternate rows are the rule. (Where the trash is burned, this is only to clear the land for plowing in preparation for planting.) The cost of raking the trash into alternate rows averages about 75c per acre, but on the other hand, cultivation expenses are halved. Even in sections where irrigation is practiced, the trash in alternate rows presents no insuperable problem, for only the alternating cultivated rows are irrigated. Primarily adopted to favor *Trichogramma* and reduce *Diatraea* injury, this practice has now become general in Puerto Rico. (*Footnote contributed by Dr. Geo. N. Wolcott, Insular Experiment Station, Rio Piedras, P. R.*)

addition of inorganic nitrogen with the cane trash at the rate of 5 pounds of nitrogen per ton of fresh field trash and the incorporation of the mixture within the surface 5 inches of soil, the rate of decomposition will be increased and the presence of available soil nitrogen insured. Since the nitrate nitrogen disappears from the surface soil during the winter and spring, an early application of the trash alone with the supplemental nitrogen being added in the spring directly ahead of the crop would prove the more practical method for the use of trash.

"The application of cane trash to the soil increased the soil nitrogen and organic matter The gain in the soil nitrogen from the use of trash was, within the limit of experimental error, equivalent to the nitrogen content of the trash.

"The resultant decomposition following the application of trash increased the availability of phosphorus 15 to 20 pounds per acre during the earlier stages of decomposition."

Frankly speaking, the sugar planters of Louisiana have not adopted our recommendation to preserve the cane trash Agronomists and bacteriologists have now come to our aid, as shown in the quotations just presented It may be that we will have to call in the services of inventors, and machinists to produce a machine which will shred or chop the trash so that it will give no trouble in cultivation So far as I know, the sugar planters have never doubted that non-burning results is at least a partial control of the borer, as we claim. They have objected to it on account of the trouble the trash may cause in subsequent cultivation. However, there is a new interest in the subject, and it seems doubtful whether cane growers can much longer afford wastefully to burn up so much material of fertilizing value as well as so many beneficial insects.

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Aphis Lion Predators of the Potato Psyllid. Aphis lions have been observed to destroy psyllid nymphs under field conditions. A half-grown aphis lion (*Chrysopa* sp.) was placed in a 3-dram homeopathic vial with 14 adult potato psyllids, *Paratrioza cockerelli* (Sulc). The aphis lion immediately seized a psyllid and fed upon it for 13 minutes. Four minutes later a second psyllid was captured, the mandibles being first sunk ventrally into the body, one into the thorax and the other into the abdomen. The position of the mandibles was shifted several times during the course of feeding, the front tarsi sometimes being used to shift the prey. Feeding lasted for two minutes. Another psyllid was captured two minutes later and fed upon for nine minutes. The next psyllid was captured in less than one minute, its dead body being discarded at the end of four minutes of feeding. Two minutes later another psyllid was captured. During the nine minutes of feeding the aphis lion frequently changed the position of its mandibles, leaving the psyllid in a very much mangled condition. This predator killed and sucked the fluids from five *P. cockerelli* adults in 46 minutes. Another aphis lion was placed in a 3-dram vial with a number of *P. cockerelli* nymphs; within 35 minutes nine nymphs had been killed, the feeding interval upon each being 2, 2, 1, 2, 4, 1, 2, ½, and ½ minutes to each one, respectively.

GEORGE F. KNOWLTON, *Utah Agricultural Experiment Station*

Beech injured by borers. The beech limb borer (*Xylotrechus quadrimaculatus* Hald.) has been attracting notice the past few years, though previously it was a somewhat unknown insect. It has come to attention through its boring in and pruning off limbs of beech at Wenham, Mass., New Canaan and Greenwich, Conn. The infested limbs are often two inches in diameter and are cut off in much the same way as by the rather common oak and maple twig pruner. This insect appears to be local in habit, and in the course of a few years may become sufficiently abundant as to seriously mutilate good sized trees. The eggs, according to the observations of Messrs. Champlain, Kirk and Knull, are laid in crevices of the bark, and in healed over injuries in the branches, from the last week in May to the middle of June. The borers winter in the branches, consequently systematic pruning and burning is a promising control.

The two-lined chestnut borer (*Agrilus bilineatus* Web.) or a closely related species, has been observed working in beech limbs at Greenwich, Conn., in the vicinity of Westbury, L. I., and at Wilmington, Del., killing individual branches and marring the symmetry of the tree. In one instance a sickly European hornbeam showed transverse ridges at the base of the larger branches, produced probably by this species, and a number of the smaller branches were in a dead or dying condition.

E. P. FELT

EXPERIMENTS IN THE CONTROL OF THE CORN EARWORM, *HELIOTHIS OBSOLETA* (FABR.), WITH *TRICHOGRAMMA MINUTUM* RILEY

By Robert K. Fletcher, *Texas Agricultural Experiment Station*

Abstract

Studies in the dispersion of *Trichogramma minutum* in cornfields and two experiments in the control of the corn earworm with *Trichogramma minutum* are described.

The serious damage done by *Heliothis obsoleta* to corn is well known. As a concrete illustration, in seven fields under observation near College Station, Texas, in 1931, an average of 95 per cent of the ears were injured. It is not unusual in making examinations late in summer to find 100 per cent of the ears at a point damaged The eggs of the corn earworm, especially those laid upon the silks, are frequently found to be parasitized by *Trichogramma minutum*. This parasitism tends to increase as the season advances; 50 per cent of the eggs deposited on the silks of late corn are often parasitized. This suggests the possibility of using Trichogramma for the control of the earworm It was with this idea that the following experiments were made.

In 1931 several attempts were made to determine the amount of spread of Trichogramma from certain points of release. All of these releases were made in field corn in the silking stage. Angoumois grain moth eggs parasitized by Trichogramma were placed in gelatin capsules which were pinned to the underside of a corn leaf in such a manner that the parasites could escape as they hatched. Care was taken to place the capsules adjacent to a silk bearing earworm eggs. Each capsule contained 100 or more parasitized grain moth eggs. Earworm oviposition records were taken at each point of release and the amount of egg parasitism recorded. Checks were selected at varying distances and the same records taken. During the season similar Trichogramma releases were made at 140 points in corn by distributing one capsule at each point. No increase in egg parasitism was found at any point. This was probably because the number of parasites released at each point was not great enough. Considerable trouble was experienced with the capsules collapsing because of heat and moisture. Grasshoppers were observed gnawing holes in the capsules although it was not determined whether or not they ate the parasitized eggs. Lady beetles and the predacious bug, *Orius insidiosus* (Say), however, entered through these holes and were observed to feed on the eggs. In a majority of cases, however, the Trichogramma succeeded in emerging successfully.

In 1932, two experiments were carried out with the definite idea of controlling the corn earworm with *Trichogramma minutum*, if possible. The first of these experiments was undertaken in sweet corn on the Central State Farm at Sugarland, Texas. The Trichogramma for this experiment were secured from Dr. A. W. Morrill, Los Angeles, California. They were of the Louisiana strain. The parasitized grain moth eggs were shipped from Los Angeles by airplane, shipments being arranged so that the parasites would begin to emerge a few hours after arriving. As soon as emergence was well underway, they were placed in an electric refrigerator and kept at a temperature between 38° and 40° F. They were kept at this temperature for 36 hours in one case with no effect on subsequent emergence nor any increase in number of males. A few hours before the parasites were to be released in the cornfields, they were removed from the refrigerator and emergence allowed to continue. The Trichogramma were shipped in capsules, at least 500 parasitized Angoumois grain moth eggs in each capsule. Several cards of eggs from which parasites had emerged were examined, and about 98 per cent of the eggs had each produced a parasite.

Five plots of one acre each were selected at the west end of the above field of sweet corn in which to release Trichogramma. Three plots adjoining these on the east were selected as checks. Earworm oviposition on corn silks is continuous from the time the first silks appear until only dry silks are left in the field. It was decided, therefore, to release Trichogramma at intervals of a few days. It was thought that it might be possible thus to insure the parasitism of the first eggs laid and to build up a high rate of egg parasitism in the field. The first Trichogramma were released the day following the first appearance of silks. Two thousand Trichogramma were released in each of the five plots on the following dates: May 23, May 27, and June 3, a total of 6,000 parasites per acre. The parasites were released by removing the end of the capsule and walking back and forth across each acre, holding the capsule with the open end up in the hand. By watching carefully, it was possible to see the Trichogramma take flight and to so gauge the rate of walking that an even distribution throughout the field would be secured. Releases were made at approximately 8 o'clock in the morning.

At each Trichogramma release oviposition records were taken, and the per cent of egg parasitism as shown by black eggs was determined. In making egg counts, only the silks, ears, and leaves and stalks adjoining the ears were examined. Records were also taken of the number of fresh silks and the number of dry silks per 100 stalks. After fresh silks appear in the corn, very few eggs are found on the stalks. The records sum-

marized in Table 1 indicate the distribution of eggs and egg parasitism in the field.

TABLE 1. RELATION BETWEEN RELEASES OF *Trichogramma minutum* IN SWEET CORN AND PER CENT OF PARASITIZED *Heliothis obsoleta* EGGS AND AVERAGE NUMBER OF CORN SILKS PER 100 STALKS, SUGARLAND, TEXAS, 1932

Date	Fresh silks Number	Dried silks Number	H. obsoleta eggs Number	Parasitized eggs Per cent
	Average for five acres			
*May 23 .	16.4	——	15.8	——
*May 27..	72.6	——	44.0	4.5
May 29..	128.2	——	95.8	15 9
*June 3...	227.0	——	60.6	25.4
June 8 ..	246.6	136.4	1 2	25.0
	Check Average for three acres			
May 23..	10.6	——	10 6	—-
May 27..	81.0	——	30.6	——
May 29..	164.6	——	87.3	1.1
June 3...	264.6	——	58.6	26.1
June 8...	260.6	135.3	9.3	7.1

*Trichogramma released on these dates.

On June 10, two hundred ears were pulled from each of the acres in which Trichogramma were released and from each acre of the checks. These were examined for injured ears by stripping back the shucks. The per cent of injured ears on the acres where Trichogramma had been released was found to be 86.2; on the checks the per cent of injured ears was 81.5. No control by Trichogramma was shown. These data are summarized in Table 2.

TABLE 2. *PER CENT OF INJURY, NUMBER OF EARS WITH ONE, TWO, THREE, OR FOUR WORMS PRESENT, AND NUMBER OF EARS WITH DEAD WORMS PRESENT. EXPERIMENT IN CONTROL OF THE CORN EARWORM AT SUGARLAND, TEXAS, 1932

Injured ears Per cent	Ears with worms present: 1 worm Number	2 worms Number	3 worms Number	4 worms Number	Dead worms Number
	Trichogramma release, average for five acres				
86.2	445	149	25	5	—
	Check, average for three acres				
81.5	224	59	11	1	17

*Data based on examination of 200 ears per acre.

The second experiment was carried out in field corn in the Brazos River Bottoms near College Station, Texas. Here three plots of one acre each were selected at the south end of a 20-acre field in which to release Trichogramma. Adjoining these on the north three acres were selected as check plots. Trichogramma were released in the first three plots on June 27, June 30, and July 8. The first two releases were at the

rate of 4,000 parasites per acre and the last release was at the rate of 2,000 per acre, making a total of 10,000 parasites per acre. These Trichogramma were also secured from Dr. A. W. Morrill and were of the Louisiana strain.

The same records were taken as in the first experiment. These are summarized in Table 3.

TABLE 3. RELATION BETWEEN RELEASES OF *Trichogramma minutum* IN SWEET CORN AND PER CENT OF PARASITIZED *Heliothis obsoleta* EGGS AND AVERAGE NUMBER OF CORN SILKS PER 100 STALKS. COLLEGE STATION, TEXAS, 1932

Date	Fresh silks Number	Dried silks Number	H. obsoleta eggs Number	Parasitized eggs Per cent
		Average for three acres		
June 27 ..	4	0	7.3	—
June 30 .	33 6	0	34.6	10.5
July 5	73 6	0	47.6	—
July 8 . .	80.3	16	18.0	—
July 12	69.6	42	9.6	—
		Check Average for three acres		
June 27	4.6	—	6.6	—
June 30	23.3	—	25.3	—
July 5	69 3	—	23 3	7.1
July 8	74.6	—	33.3	—
July 12	72 6	27.6	34.0	2.9

It will be seen that the amount of egg parasitism in either the experimental plots or the check plots was very low and did not increase as at Sugarland

On July 12, two hundred ears were pulled from each plot and examined for injury and ears with worms present. It was found, as shown in Table 4, that 69 per cent of the ears on the plots where Trichogramma had been released were injured, while on the check plots 75 per cent were injured. In connection with the per cent of injured ears on the check, one of these plots showed only 62 per cent of the ears injured. The other two plots of the check had 81 per cent and 82 per cent injured ears, respectively. It is possible that there was some spread of Trichogramma with the prevailing wind into plot 1 of the check.

TABLE 4. PER CENT OF INJURY, NUMBER OF EARS WITH ONE, TWO, THREE, OR FOUR WORMS PRESENT, AND NUMBER OF EARS WITH DEAD WORMS PRESENT. EXPERIMENT IN CONTROL OF THE CORN EARWORM AT COLLEGE STATION, TEXAS, 1932

Injured ears Per cent	1 worm Number	2 worms Number	3 worms Number	4 worms Number	Dead worms Number
		Trichogramma release, average for five acres Ears with worms present			
69.0	138	24	3	3	34
		Check, average for five acres			
75.0	156	26	6	0	52

The only conclusion which can be drawn from these two experiments is that in neither case was the number of Trichogramma released per acre sufficient to give control of the corn earworm. In the first experiment the check plots showed more uninjured ears than the plots in which the parasites were released. In the second experiment, while there was a gain in uninjured ears in the plots where parasites were released, this was not greater than the variation in number of uninjured ears in the check plots.

LARVAL PARASITES OF THE ORIENTAL FRUIT MOTH IN ROANE COUNTY, TENNESSEE

By H. G. Butler, *U. S. Bureau of Entomology*[1]

Abstract

Seventeen species of larval parasites of the oriental fruit moth have been reared from twig-infesting larvae in Roane County, Tennessee. Only one of these, *Macrocentrus delicatus* Cress., is, however, sufficiently abundant to be of importance as a control factor. Over 95 per cent of the parasites reared in this investigation have been of this species.

While 27 colonies, including 6 species, of oriental fruit moth parasites have been liberated in the past three years, none of these species have been recovered in sufficient numbers to indicate that they are effective in this district.

The development of the earlier broods of the oriental fruit moth (*Grapholitha molesta* Busck) in peach twigs, together with the feeding habits of the newly hatched larvae, have made the sprays and dusts commonly used in peach orchards of little value. The practical impossibility of maintaining an effective poison coat over rapidly growing twig terminals during the spring and early summer permits the propagation of two full broods of this pest before the twigs harden and a general attack on the ripening fruit occurs. During this long period the only restrictive forces now known to be effectively operating are those exerted by weather conditions and natural enemies.

The most important of the natural enemies of the oriental fruit moth, during the spring and early summer, are the insect parasites, a large number of which have been found to attack this species in the United States. The degree of control effected by these parasites varies greatly. Some of the species concerned are of negligible importance and others are quite valuable. On the other hand, a particular species may be quite

[1]Mr. Junius C. Clark, Temporary Field Assistant, helped with the work reported in this paper during the spring and summer of 1931.

effective in one district and of minor value elsewhere. Such a condition has been found to exist in Roane County, Tennessee. The investigation of the different species of larval parasites of the oriental fruit moth present in this area and of the importance of each as a control factor was started in 1930 and continued throughout 1931 and 1932.

Records of 1930 and 1931.—The larvae used in this investigation were obtained from infested peach twigs gathered in various orchards. These twigs, stripped of their leaves, were confined in battery jars with an apple to supply additional larval food if needed. In 1930 and 1931 the larvae, as they matured, were placed in pupation racks for subsequent observation. In these two years parasitization was determined by the emergence of the parasite larva from the host larva, and not by the emergence of the adult parasite. All oriental fruit moth larvae that entered the pupal stage were counted as normal. The adult parasites that emerged were preserved for later identification. The species determinations herein reported were made by J. M. Aldrich, R. A. Cushman, and C. F. W. Muesebeck, all of the Taxonomic Unit of the Bureau of Entomology, at Washington, D. C. A summary of the records of 1930 and 1931 showing the degree of parasitization found in larvae maturing in each of the spring and summer months is given in Table 1.

Table 1. The Degree of Parasitization Found in Larvae of the Oriental Fruit Moth Maturing in the Spring and Summer Months of 1930 and 1931

	1930				1931			
	Number of larvae		Per cent		Number of larvae		Per cent	
Month	Normal	Parasitized	Normal	Parasitized	Normal	Parasitized	Normal	Parasitized
May.....	—	—	—	—	13	0	100.0	0.0
June.....	—	—	—	—	604	255	70.3	29.7
July......	46	48	48.9	51.1	1,075	1,317	44.9	55.1
August...	97	444	17.9	82.1	68	249	21.5	78.5
September	5	56	8.2	91.8	—	—	—	—
Total...	148	548	21.3	78.7	1,760	1,821	49.1	50.9

The total percentage of parasitization, as determined from the records of July, August, and September of 1930, is 78.7, and that for 1931 is 50.9. The omission of records for the months of May and June in 1930 results in a distorted rate of parasitization for that year. The degrees of parasitization in July and August do not vary greatly in the two years. The difference in total percentage of parasitization for the two years is due to the inclusion of data for September in 1930 and for May and June in 1931. An expression of the rate of parasitization found during the year, based on the records of all larvae under observation during the season, is greatly influenced by the variation in the numbers of larvae in each of the several periods. A more accurate interpretation of the con-

ditions is obtained from the rate of parasitization found in the same month for the seasons compared.

RECORDS OF 1932.—A few infested twigs, noted prior to May 7, were collected and placed together as a miscellaneous lot. The first parasite to emerge during the season, *Lixophaga mediocris* Ald., of the dipterous family Tachinidae, came from these twigs.

By May 10 infested twigs were sufficiently abundant to permit their collection for insectary use. The first moth emergence from these twigs occurred May 27, and the first hymenopterous parasites, *Macrocentrus delicatus* Cress., emerged June 13, from twigs collected May 18 and 19. Several days later parasites emerged from twigs collected May 17. No hymenopterous species were reared from twigs collected before this date. It is thus shown that these parasites were ovipositing in the orchard by May 17.

In 1932 infested twigs were confined in battery jars with narrow strips of corrugated paper, and as the strips became partially filled by fruit moth larvae they were removed to a second jar to be held until moths and parasites emerged. However, some emergence occurred in the twig jars, as part of the larvae constructed cocoons in the twig bundles. Parasitization was determined by the emergence of the adult parasites. A summary of the emergence of moths and parasites reared from twig-infesting oriental fruit moth larvae collected each month during the spring and summer of 1932 is given in Table 2.

TABLE 2. THE EMERGENCE OF MOTHS AND PARASITES REARED FROM TWIG-INFESTING ORIENTAL FRUIT MOTH LARVAE COLLECTED IN ROANE COUNTY, TENN.

Month collected	Number of samples	Number of moths	Number of parasites	Total emergence	Per cent parasitization
May.	15	1,279	536	1,815	29.5
June.	31	3,380	2,937	6,317	46.5
July	37	599	2,399	2,998	80.0
August.	18	81	202	283	71.4
Total	101	5,339	6,074	11,413	53.2

The rearing records of 11,413 larvae under observation show that the total parasitization for the season was 53.2 per cent. No parasites were reared from twigs collected between May 10 and 16, but following this period the degree of parasitization rapidly increased until the latter part of July. The maximum degree of parasitization occurred in the interim between July 19 and 25. Rearing records obtained from 17 twig samples collected in this period show that 84.4 per cent of the larvae were parasitized.

PARASITIZATION IN THE FRUIT-RIPENING PERIOD.—A relatively small number of oriental fruit moth larvae attack immature peaches prior to the ripening period. It is not until late in the season that a general infestation of peaches by these larvae occurs. This period normally extends from mid-July until all fruit is removed from the orchards, which may be, in this area, late in August.

The moths emerging from July 8 to August 4 are the immediate progenitors of the fruit-infesting larvae. Records of 1932 show that of the 1,942 larvae from which either moths or parasites emerged during this time 1,346, or 69 per cent, were parasitized. This high rate of parasitization, affecting the most critical part of peach development, the ripening period, affords a more accurate measure of the practical results of oriental fruit moth control by parasites than is given by records for the complete season.

TABLE 3. SPECIES AND NUMBER OF PARASITES OF THE ORIENTAL FRUIT MOTH REARED EACH YEAR IN ROANE COUNTY, TENN.

Species reared	Order	Family	Number of specimens reared 1930	1931	1932	Total
Campoplex sp.	Hymenoptera	Ichneumonidae	-	-	2	2
Cremastus n. sp.[1]	Hymenoptera	Ichneumonidae	-	-	1	1
Cremastus minor Cush.	Hymenoptera	Ichneumonidae	-	1	4	5
Cremastus n. sp.[2]	Hymenoptera	Ichneumonidae	-	10	47	57
Cremastus tortricidis Cush.	Hymenoptera	Ichneumonidae	-	-	5	5
Diocles obliteratus Cress.	Hymenoptera	Ichneumonidae	-	-	2	2
Eubadizon pleurale Cress.	Hymenoptera	Braconidae	-	-	10	10
Eubadizon sp.[3]	Hymenoptera	Braconidae	-	2	-	2
Eurytoma sp.	Hymenoptera	Eurytomidae	-	-	3	3
Glypta rufiscutellaris Cress.	Hymenoptera	Ichneumonidae	-	2	26	28
Lixophaga mediocris Ald.	Diptera	Tachinidae	-	3	10	13
Macrocentrus ancylivorus Rohw.[4]	Hymenoptera	Braconidae	26	18	1	45
Macrocentrus delicatus Cress.	Hymenoptera	Braconidae	441	1,550	5,820	7,811
Macrocentrus instabilis Mues.	Hymenoptera	Braconidae	26	-	22	48
Microbracon mellitor Say	Hymenoptera	Braconidae	--	2	--	2
Pristomerus agilis Cress.	Hymenoptera	Ichneumonidae	-	-	70	70
Pristomerus ocellatus Cush.[4]	Hymenoptera	Ichneumonidae	1	8	49	58
Secodella n. sp.	Hymenoptera	Eulophidae	-	-	7	7
Undetermined[5]	Diptera	———	-	9	-	9
Total			494	1,605	[6]6,079	8,178

[1]Reared by H. W. Allen from twigs collected in Roane County, Tenn.
[2]At least two unnamed species are present.
[3]Probably E. pleurale Cress.
[4]Introduced species.
[5]Probably L. mediocris Ald.
[6]Includes 5 specimens not listed in Table 2.

Species of Parasites Reared —During the past three years 17 parasitic species, naturally present in this district, have been reared from oriental fruit moth larvae obtained from infested peach twigs collected in the various orchards. With one exception, these parasitic species are of minor importance as a control factor. A tabulation of the number and species of parasites reared each year is given in Table 3.

Macrocentrus delicatus is the most important of the larval parasites of the oriental fruit moth in Roane County, Tenn Over 95 per cent of the 8,000 parasites reared in this investigation have been of this species.

Introduction of Parasites —In cooperation with H. W Allen, of the Moorestown, N. J , laboratory of the Bureau of Entomology, several parasitic species under investigation at that station have been liberated in Tennessee orchards Recoveries have been made from 6 of the 27 colonies of oriental fruit moth parasites liberated in the past three years The results from 17 of these colonies, liberated in 1932, will not be available until 1933.

Two colonies of *Macrocentrus ancylivorus* Roh. were introduced in 1930 and 26 specimens were recovered in the same season In 1931 four more colonies were liberated and 18 specimens were reared from field-collected larvae Six additional colonies were liberated in 1932 and a single recovery was made The specimen taken in 1932 came from an orchard in which a colony was liberated in 1930

Three colonies of *Pristomerus ocellatus* Cush. were liberated in 1931. This species is naturally present, in small numbers, in Tennessee, and, in 1932, 49 specimens were taken in 8 widely separated orchards, including two of those in which colonies were released.

A single colony of *Pristomerus vulnerator* Panz , a European species, was available late in the season of 1931. It was liberated under unfavorable conditions. No specimens have been recovered.

Seven colonies of *Ascogaster quadridentatus* Wesm., a European species which oviposits in the egg of its host, were introduced in 1932. No specimens have been recovered.

Two colonies of *Trichogramma euproctidis* Gir., a European egg parasite, were introduced in 1932. No recoveries have been made.

Two colonies of *Perisierola* sp., an Australian parasite of the oriental fruit moth, were released late in the season of 1932. No specimens have been recovered.

Indifferent success has attended the introduction of parasitic species in this area. *Macrocentrus ancylivorus* Roh., quite valuable in New Jersey, has been unable to increase in numbers in eastern Tennessee.

The single specimen taken in 1932 shows that, while the species has successfully lived over two winters, the population is declining.

The habits of the oriental fruit moth in this district are such that an alternate host seems to be necessary for the success of larval parasites. The abundance of *Macrocentrus delicatus* may indicate the presence of a host suitable for that species but not for *M. ancylivorus*.

A METHOD FOR TIMING SPRAYS FOR THE CONTROL OF SCALE INSECTS ON CITRUS[1]

By L. L. English and G. F. Turnipseed,[2] *Alabama Agricultural Experiment Station, Field Laboratory, Spring Hill, Alabama*

Abstract

Sprays for the control of scale insects were effectively timed from weekly records of the abundance of crawlers. Such records were made by counting the number of crawlers caught in removable tanglefoot bands placed on infested branches of satsuma orange trees.

Considerable importance has been attached to the timing of sprays for the control of the Codling Moth (*Carpocapsa pomonella* L.) and perhaps a few other insects, but proper attention has not been given to the timing of oil sprays for the control of scale insects. For maximum control with a minimum amount of oil, it is essential that the spray be timed to kill the greatest number of crawlers. In the case of an insect having only one or two generations a year, the problem is relatively simple, but when there are several generations each season, with much overlapping, there is need for quantitative data. The procedure herein reported has been used successfully for two years for timing sprays for the control of scale insects on citrus.

Procedure.—Records are obtained by making weekly counts of the number of scale crawlers caught in removable tanglefoot bands. Three bands are used on each record tree, each band being placed on wood of a different age. Care should be exercised in selecting branches which have an adequate infestation of disease-free scales. The location for the band is scraped free of scales. A strip of transparent mending tape one-fourth inch wide is placed smoothly and tightly around the limb. This is brushed over with a coating of collodion. After the collodion dries a narrow thread of tree tanglefoot is placed around the middle of the band with a hard rubber syringe (Plate 46).

[1]Journal paper from Department of Zoology-Entomology, Auburn, Alabama.
[2]Assigned by Alabama State Department of Agriculture.

On the same day of each week the bands are carefully removed with a spearheaded needle and forceps, pinned in a Schmitt box, and carried to the laboratory for examination. New bands are put on in the same place each week. When one is working with purple scale (*Lepidosaphes beckii* Newm.), long scale (*L. gloverii* Pack.), or chaff scale (*Parlatoria pergandii* Comst.), the bands may be located on the same branches for an entire season. With camphor scale (*Pseudaonidia duplex* Cockll.), however, the bands should be re-located when the number of crawlers is at a minimum, due to the migration of the scale population.

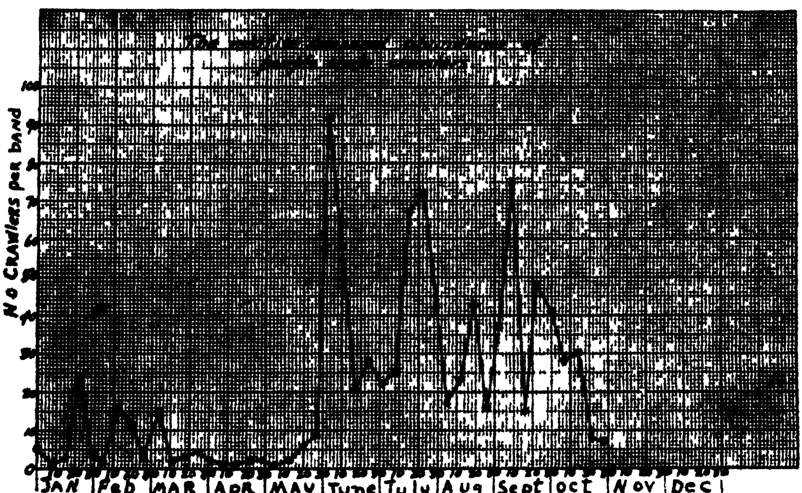

Fig. 83. Seasonal abundance of purple scale crawlers.

The prediction of a peak hatch becomes easier with experience and increased data. It has been our practice to wait until the week following each peak before advising growers to spray. At that time a high percentage of the scale population is in a susceptible stage. After the first peak of the season has been obtained, the succeeding peaks can be predicted rather accurately from a knowledge of the length of the life cycle or by rearing adults in the insectary from crawlers secured at the peak of hatching.

Results.—Eggs of the purple scale continue to hatch throughout the mild winters of South Alabama, and although there is considerable overlapping of generations, there are three peak hatches during the summer season (Fig. 83). Since at the time of the first peak the satsuma oranges are too small for oil, lime sulphur is applied; at the other two peaks oil is

Removable tanglefoot band on Satsuma branch.

used. By following this procedure a high percentage of clean fruit has been obtained even in heavily infested orchards.

It was found that camphor scale could also be controlled quite readily with the aid of this method. Unlike purple scale, this insect does not hatch throughout the winter; moreover, the three summer broods are more distinct and without the overlapping found in purple scale. In the first year's work with this pest the spray was applied without attention to timing. An almost complete failure resulted as the adult females are difficult to kill. During the following two years, sprays were properly timed and a high infestation was brought under satisfactory control.

The procedure described for determination of abundance of crawlers also offers a means of studying the seasonal history of scale insects. It may also be used for the determination of the degree of infestation or for the measurement of the relative effectiveness of sprays which have been applied to large blocks of trees.

A STUDY OF THE EFFECT OF ACCESSORY SUBSTANCES ON THE ADHERENCE OF LIME SULFUR SPRAY TO THE INTEGUMENTS OF PINE LEAF SCALE, *CHIONASPIS PINIFOLIAE* (FITCH)[1]

By WILLARD W. YATES, *Portland, Ore.*

ABSTRACT

A number of common spreaders and adherents are here tested out in lime sulfur spray for their effect in increasing or decreasing the amount of adhering spray solution on the integuments of pine leaf scale. The method used in estimating the relative value of the various combinations was to determine quantitatively, by an adapted colorimetric method, the residual sulfur left deposited on fifty scales. It is apparent from the experimental results that the correct amount of accessory material to use is important, and will depend upon the nature of the surface to be covered. The integument of the pine leaf scale is not difficult to wet. The use of an excessive amount of certain materials with lime sulfur resulted in a reduction in the amount of adhering sulfur. From an economic standpoint, it is evident that the use of an excessive amount of accessory material in a spray is a more serious error than the use of too little material.

The adherence and spread of contact sprays and the physical and chemical forces involved in the process has received considerable atten-

[1]Submitted to the Oregon State Agricultural College in partial fulfillment for the Degree of Master of Science, June 1932.

Credit is due Prof. D. C. Mote and Prof. R. H. Robinson of the Oregon State College for their helpful suggestions and criticisms.

tion. However but little work has been undertaken as to the actual amount of spray solution that adheres to treated surfaces, especially the integuments of insects. In this study lime sulfur spray with and without accessory substances added to it was applied to scale insects, and the residual amount of adhering sulfur quantitatively determined. Sprays when applied to insects leave residual amounts both as external deposits and often as internal penetrants. Present laboratory technique does not permit the determination of the one and not include the other The data here submitted is a measure of the total spray residue left either on or in the insects treated. Conclusions arrived at are based on the experimental data secured, but in a final evaluation of a spray solution, the other physical and chemical factors involved must all be taken into consideration. The quantity of spray left adhering to the integument of insects is considered to be important, and the magnitude of this deposit should be of aid in determining the relative value of the several spray combinations

The terms, spreaders, adherents, wetters etc , have been employed to convey slightly different relationships between the spray and the surface it is applied to. The terms, spreaders and adherents, are here used to indicate groups of substances that are usually used either to give improved coverage and film or to cause the spray to adhere better to the sprayed surface. No attempt is made to classify the materials either before they are used or on the basis of the data secured

Experimental Data —A high grade commercial brand of lime sulfur with an adjusted Baume of 31.5 degrees was used in all the tests. This concentrated solution was diluted to give a one to ten solution. This final solution was prepared fresh for each spray combination, and was used as soon as possible after being made Most of the spreaders and adherents selected for trial are commonly used ones, and have specific recognized values. Selection was made to include materials with widely differing physical and chemical properties. Certain materials were tested because of specific requests from other workers. The amount of the various substances to use is important, and this point was very forcibly brought out during the progress of this work. The non-homogeneous mixtures obtained with the oils and lime sulfur were decidedly against their use. In a large spray tank with higher agitation better mixtures would be obtained than in the laboratory. In order to satisfactorily use the oils, they were first emulsified with .05% of Kayso Spreader. The resulting emulsions were not very permanent, but allowed the oil-lime sulfur combinations to be applied to the insects.

The pine leaf scale, *Chionaspis pinifoliae* (Fitch), was selected for the

first study. This scale is larger than either the San Jose or oyster shell scales, and is also more easily removed from the leaves without adhering tissue. A fresh supply was available during the season of the year this work was being done. According to Metcalf (2), these scales and the oyster shell scales are very similar in composition in as far as wax composition is concerned. These scales are reported to contain 40% of wax and the oyster shell scales 35%. Mature live scales were used in these tests. The spray solutions were prepared in 100 cc lots and a medium size test tube was filled with the solution. Pine needles carrying an excess of scales were tied into loose bundles, and these were immersed in the liquid, immediately removed, and hung on a rack to drain and dry. Fifty scales were then singly and cleanly removed for each test and brushed into the container used for the determinations.

Owing to the small amount of sulfur adhering to the scales, a colorimetric method of determining this sulfur was employed. This method was one modified and adopted by the Agricultural Chemistry Department of Oregon State College for use in determining the sulfur residue left on fruits (1) This method was slightly modified to adapt it to this work. The fifty scales were placed in 100 cc test tubes and 10 cc of 2% caustic soda solution added They were kept near boiling point for a half hour or longer to bring the sulfur into solution. After cooling 40 cc of hydrochloric acid (1 part conc. acid to 4 of water) was added together with 2 grs. of sulfur free zinc The tubes were connected up by means of stoppers with modified Gutzeit tubes and acid catch tubes. The upper tube was 1/8 inch bore and in it was placed a hardened strip of filter paper that had been treated with a 5% lead acetate solution. The reduced sulphide released as hydrogen sulfide reacted with the acetate to give a characteristic black stain of lead sulfide on the paper. These stains were compared with standard stains made using known amounts of sodium thiosulfate. Blanks were run on the untreated insects and the reagents.

The results of these tests made on scale insects are reported in Table 1. The average results of the several analyses are given in the fifth column as milligrams of sulfur and then these figures, after correcting for the blank, are used in graphically showing the relationship between the various combinations by the solid horizontal lines drawn to scale.

All tests were made in an upstairs laboratory and temperature and humidity varied within a narrow range. Records of these were kept, but as no correlation seemed to exist between them and the results secured, they are not included here.

TABLE 1. RESULTS OF SULFUR DETERMINATIONS WITH FIFTY SCALE INSECTS USING VARIOUS SPRAY SOLUTIONS

Spreaders and adherents used with 1 to 10 lime sulfur solution	Am't used %	Duplicate determinations (Length stain in mm.)		Ave. stain	Mgs of sulfur	Results graphically presented 0.1 mg. of S = 5 cm. (Corrections for blank deducted)
Lime sulfur only	—	38.5	45.0			
		38.5	48.0			
		37.0		41.4	.082	
Blank on reagents plus scales	—	2.0	1.4			
		1.1	1.6	1.3	.0266	
Prepared Calcium caseinate (4 pts. casein to 1 lime)	0.5	41.0	38.0			
		33.0		37.3	.0739	
same	0.1	52.0	51.5	51.7	.1035	
same	0.05	48.0	70.0			
		56.0		58.0	.1164	
Dried skim milk	0.1	45.0	50.0			
		52.0		49.0	.0979	
Fresh liquid skim milk	1.0	42.5	40.0			
		57.0		46.5	.0926	
Blood albumin (tech.)	0.5	38.5	27.5			
		33.0		33.0	.065	
same	0.1	43.0	55.0			
		44.0		47.3	.0945	
same	0.05	38.0	44.5	41.3	.082	
White Dextrin (tech.)	1.0	39.0	36.5	38.7	.0768	
same	0.5	57.0	55.0	56.0	.1122	
Soluble Starch (tech.)	1.0	36.0	37.5			
		26.5		33.3	.0656	
same	0.5	53.5	59.5			
		35.8		49.6	.099	
Gelatine (tech.)	0.5	43.0	37.0			
		39.5		39.5	.079	
Saponin (C.P.)	0.5	34.0	28.0			
		35.0		32.3	.0636	
same	0.05	38.7	51.5			
		68.5		52.9	.1058	
Hard Wheat Flour	1.0	48.0	50.0			
		40.5		49.5	.099	
same	0.5	41.0	41.5	41.3	.082	
Kaolin (acid washed)	1.0	55.0	51.0			
		40.0		48.7	.0972	
Pipe Clay (potters)	1.0	53.0	52.0			
		40.5		48.5	.0969	
Sodium Silicate (tech.)	1.0	78.5	79.5			
		59.0		72.3	.1455	
*Waste sulfite liquor residue	1.0	26.0	25.8			
		41.5		31.1	.0555	
Cottonseed Oil + .05% Kayso	1.0	53.5	57.0	55.3	.1108	
Linseed Oil + .05% Kayso	1.0	61.5	82.0			
		74.0	44.0	65.4	.1315	
Fish Oil + .05% Kayso	1.0	42.0	39.5			
		75.5	75.0	58.0	.1162	
Fish oil resin spreader	0.5	24.4	32.0	28.2	.0552	
Kayso Commercial spreader	0.5	31.5	30.5	31.0	.0609	
	0.05	61.0	70.5			
		59.3		63.6	.1277	

*Blank for this was 4. Omm, a product prepared from waste sulfide liquor from paper mill.

Discussion and Conclusions.—A study of the table shows that of the 28 combinations used on the insects, 16 gave an increase in residual sulfur over that given by lime sulfur alone, 4 gave approximately the same, and 7 gave less. The oils and the sodium silicate combinations proved to be the best in so far as total sulfur is concerned. The drying linseed oil gave a higher deposit than either the semi-drying fish oil or the cottonseed oil. Dried skim milk at 0.1% gave nearly the same results as liquid skim milk at 1.0% concentration. It required more blood albumin than calcium caseinate to get as good a coverage. Some of the materials that were experimented with and gave poor or indifferent results at the concentrations used would probably at a higher or lower level make a better showing. It was not possible because of the time limit to test a wide enough range of concentrations, nor use the substances with any other spray solution besides lime sulfur, and therefore the actual evaluation of the various substances for competitive value cannot be made.

Marked differences occurred where the amount of certain accessory materials was varied. Calcium caseinate at 0 5% gave less adhering sulfur than the lime sulfur alone, 0.1% improved the coverage, while the 0 05% concentration gave the greatest amount of residual sulfur. Blood albumin used in the varying amounts did not show such extreme values, but the intermediate concentration of 0.1% gave better coverage than either the stronger or weaker mixtures Combinations of several of the accessory materials where more than one concentration was tested also bring out the importance of using the proper amount of a spreader or adherent

These tests with the various spray combinations have shown that the amount of accessory substance that is added to a given spray solution is very important. Materials chiefly valuable for their spreading properties will undoubtedly have more effect on a spray solution, when the amount used is varied, than those substances that are primarily adhesives. Woodman (4) has gone into this question of influence of accessory substances in spray combinations rather extensively. He defines as the "critical surface tension," the point where the surface tension of the liquid has been reduced, and the maximum amount of a spray fluid is retained. Failure to reach this point results in imperfect wetting and after it is reached, surface tension ceases to be a dominating factor influencing the volume of liquid retained by a surface. The results reported here show that there is a point, corresponding to the critical surface tension point of Woodman's, where the amount of material used results in a maximum deposit of spray and if more material is

used not only is no additional deposit secured, but the amount of deposited spray will actually be decreased to less than if no spreader had been used. It would appear from these findings that in actual field spraying operations the use of too little spreader from the standpoint of maximum spray deposited would not be as serious a mistake as the addition of an excessive amount.

The integument of a scale insect represents a certain peculiar surface, but one that is not particularly hard to wet with lime sulfur as it has a certain undetermined absorptive and adsorptive power. The physical forces were not measured, but lime sulfur gave a rather even uniform coverage to the scales. Observations indicated that with the method used where the leaves were immersed and the scales drenched with solutions, there was no creeping of the spray away from the insect covering as reported by O'Kane and Conklin (3).

LITERATURE CITED

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Scientific Notes

Chinch bug (*Blissus leucopterus* **Say**). There has been serious injury the past season to lawns by this insect in southwestern New England, western Long Island, southern New York, northern New Jersey and sections in the vicinity of New York City. Lawns previously in good condition became badly spotted with brown areas. The affected grass, if nothing was done, soon died. It is possible to kill many of the insects by repeated applications of a contact insecticide, such as tobacco dust, a nicotine sulfate-lime dust or a potassium oleate and Black Leaf 40 combination. These do not kill the eggs and afford but temporary relief. There is a possibility that fumigating with a carbon disulfide emulsion under canvas will give more efficient control.

E. P. FELT

The pine tip beetle (*Pityophthorus pulicarius* **Zimm.**) has been unusually abundant and injurious to Austrian pine in particular at Greenwich, Conn., Bedford Hills, N. Y., Southampton, L. I., and in the Philadelphia area. An infestation is indicated in midsummer by some three or four inches of dead tips with brown needles. The numerous burrows made by this insect are less than a sixteenth of an inch in diameter, and not infrequently the insects may be found in the affected tips. A severe infestation appears to result in the gradual killing back from the affected tip and may

ultimately involve most of a good sized branch. A general infestation may result in most of the tips and a large proportion of the tree becoming badly browned in midsummer. This condition appears to result from an infestation of several years standing, which permits a gradual increase in the numbers of the insects and corresponding damage.

E. P. FELT

Reappearance of the Colorado Potato Beetle in Utah. The Colorado potato beetle has been reported several times from Utah (Jour. Econ. Ent. 25: 134). Small outbreaks occurring in Morgan and in Utah Counties, apparently were exterminated. This year Colorado potato beetles were found injuring potato vines in a number of fields south of Ogden, over an area of a few square miles. Only part of the potato fields were infested, but some farmers reported that this insect had been found on their potato plants during the past two to three seasons. The small area in which Colorado potato beetles were found extends to about one and one-half miles north of Riverdale, south through Roy to Sunset and Clinton, extending a short distance into both Weber and Davis Counties. The infested area is traversed by two railroad lines. It is possible that the infestations came in on railroad cars.

GEORGE F. KNOWLTON, *Utah Agricultural Experiment Station*

Preparation of Derris Extract Sprays. In preparing sprays with commercial concentrated acetone extracts of derris (containing from 2.3 to 5 grams of rotenone per 100 cc. with a total of 16 to 18 per cent derris extractives) large quantities of precipitates were formed when 1 part of the extract was added to 250 to 500 or more parts of water, soap solutions, or solutions of various other wetting agents. Not only are such precipitates apt to clog spray nozzles but it is also likely that they contain active constituents which might be less effective in such a poorly dispersed state. It was found that coagulation could be overcome and a milky dispersion of the extractives obtained by diluting the extract with acetone (1:1) before adding it to water or to aqueous solutions of various wetting agents. Residues from sprays so prepared retained their toxicity to thrips much longer when sulfonated castor oil (1:400) was used as the wetting agent instead of potassium coconut oil soap (1:300). Sulfonated castor oil (turkey red oil) at 1:400 wet effectively the foliage of various plants, including gladiolus, rose, and onion.

HENRY H. RICHARDSON, *Assistant Entomologist,*
Division of Truck Crop and Garden Insect Investigations,
U. S. Bureau of Entomology, Washington, D. C.

Specific Defoliation Data on Apple. The need for an accurate method of evaluating leaf drop on apple has never been more apparent than at present. Due to the spray residue situation, new sprays and combinations are being tried, and resultant injury is being experienced in varying degrees. Leaf drop is the most common, most definite, and most serious form of foliage injury. For several years entomologists at the Ohio Agricultural Experiment Station have experimented with different methods of securing accurate data on defoliation. This season a method has been used in which the leaves on wood of the current season's growth are considered. Defoliation almost always starts with the leaves at the base of such growth and then proceeds toward the tip. As each leaf drops it leaves a record of its former presence in the shape of a definite leaf scar. By counting such scars and the remaining leaves that

may be present an exact record of the defoliation status may be obtained. The writer has found that a count on 20 terminals per tree is a sample large enough for accuracy.

M. A. Vogel has also successfully used this method in determining relative rates of spray injury on peaches.

C. R. CUTRIGHT, *Associate Entomologist, Wooster, Ohio*

The Past and Present Status of Fluorine Containing Insecticides.[1] During 1915, there appeared two publications, one by Marlatt (U. S. Dept. Agri. Bul. 658), and another by Schafer (Mich. Agr. Exp. Sta. Tech. Bul. 21), recommending the use of sodium fluoride as a control for roaches. These two papers seem to be the first to recommend a fluorine containing salt to be used as an insecticide in the United States.

Very little was done concerning their possible insecticidal use from that date, until 1924. However, from 1924 until 1932 considerable research was carried on at several Agricultural Experimental Stations, as well as the Bureau of Entomology at Washington, D. C. The ravages of several important economic insects throughout that period may also have stimulated the discovery and recommendation of new insecticides, because of the relatively ineffectiveness of the insecticides then in use.

During 1932, there appeared several publications by Smyth and Lantz; Smyth, Lantz & Smyth (Jour. Dental Res. 12: 149–159, Ibid 12:552–556, Jour. Agr. Res. 12:554 and Dental Survey March issue), covering the chronic effects of fluorine. For a short time their data brought about a slight curtailment in the amount of research using the salts of fluorine as insecticides.

The appearance of these adverse data, seem to have brought about a sad misjudgment by some, of the entire insecticide field. The discovery of the perfect or completely satisfactory dual purpose insecticide is still something for the enthusiastic entomologist to look forward to. Results from several investigators show definitely where certain arsenicals are relatively specific for certain purposes. We must then conclude that these salts of arsenic still have, and will have for some time to come, a definite place in our insecticidal category.

As much or more can be said for the fluorine containing insecticides, since the results of Marlatt (U. S. Dept. Agr. Bul. 658:1915) and Schafer (Mich. Agr. Exp. Sta. Tech. Bul. 21:1915) have been confirmed by a goodly number of investigators.

The insecticidal use of fluorine containing compounds has been more strikingly brought forward since that time by the investigations of Roark (U. S. Patent No. 152484; 1925), Herrick (Proc. 71st Ann. meeting N. Y. State Hort. Soc.; 4217; 1926), Gentner (Mich. Agr. Exp. Sta. Bul. 155; 1926), Ripley (Bul. Ent. Res. 15:29–34; 1924), Marcovitch (Tenn. Agr. Exp. Sta. Bul. 131; 1925—Jour. Econ. Ent. 18:122–128; 1925), and numberless others who have found specific uses for several different salts of fluorine. In many instances the results obtained were far superior to other insecticides, when compared under similar circumstances.

The two latest, and possibly the most promising of these fluorine containing compounds are cryolite and barium fluosilicate. Their margin of safety for foliage application, exceedingly high toxicity to insect life, and relatively low toxicity to man, when compared with lead arsenate (Smith & Smith, Jour. Ind. & Eng. Chem. 24:229; 1932), (Sollman, Schettler and Wetzel, Jour. Pharm. and Exp. Ther. 17:197–225; 1921) and Sollman, Jour. Pharmacol. 18:43–50; 1921, have led the writer to believe that under average rainfall conditions, these two compounds definitely have a place

[1]Prepared from a review of literature pertaining to insecticides and their use.

among our insecticides. Cryolite, because of its moderate solubility (Carter, Jour. Ind. and Eng. Chem. 20:1195; 1928, Marcovitch & Stanley, Jour. Econ. Ent. 23: 370–376; 1930), seems to lend itself almost ideally when we consider the above limiting factors. To date the writer has been unable to find complete published information concerning its comparative residual effects and compatibility with other insecticides.

Let us not forget that some of these fluorine containing salts may, under certain conditions, become some of our most welcome and satisfactory insecticides.

C. M. Gwin, *Entomologist, Arwell, Inc., Waukegan, Ill.*

The Use of the Term "Pyrethrin" by Entomologists.[1] An unfortunate confusion in the use of the term *pyrethrin* exists in the literature of plant chemistry. Few entomologists are aware that this term was used first in 1876 by Buchheim[2] to designate the active principle in the roots of *Anacyclus pyrethrum* (Linn.) De C., or pellitory of medicine. Because *Pyrethrum* was for a long time also the generic name of plants which are the source of insect powder, the term *pyrethrin* has been used recently for the active principles of that insecticide. A brief survey of definitions of *pyrethrum* in recent editions of various medical dictionaries shows a real confusion in the use of the term. A few facts concerning the nature and source of pellitory and of insect powder, as well as the history of the term *pyrethrin*, will help in making clear the reason for the existence of such a condition.

Anacyclus pyrethrum (Linn.) De C., belonging to the Compositae, is commonly known as pellitory. It grows principally in northern Africa. The root is used in medicine as a counter-irritant and sialogogue, although it is stated in the Dispensatory of the United States of America[3] that this drug is very rarely employed today. Pellitory was deleted from the present United States Pharmacopoeia X, but it was included under the name *pyrethrum* in many of the earlier editions. In Europe, *radix pyrethri*, *Bertram root*, and variations of these names are used. *Anacyclus officinarum* Hayne, the root of which is known by substantially the same names, grows in Germany.

Chrysanthemum species that are the source of insecticidal pyrethrum were grown originally in southeastern Europe and southwestern Asia. In this case, it is principally the flower head instead of the root that contains the active compounds. When *pyrethrum flowers* (*flores pyrethri*) are mentioned reference is certainly to the flowers of a *Chrysanthemum* (*Pyrethrum*) species. French usage prevents ambiguity with the expression *pyrèthre insecticide*.

Prior to Buchheim's suggestion of the term *pyrethrin*, Parisel[4] in 1833 gave a similar name, *pyrétrine*, to an active resin he extracted from pellitory. Thompson[5] has been given credit by Czapek[6] (p. 294) for applying the name *pyrethrin* in 1887, although Czapek (p. 252) also refers to Buchheim's previous usage (1876). Dunstan and Garnett[7] proposed the name *pellitorine* in 1895 for the physiologically active,

[1]Published as Paper No. 1180 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.

[2]R. Buchheim, Archiv. f. Exp. Path. u. Pharm., 5: 455–462. 1876.

[3]The Dispensatory of the United States of America. 21st edition, 1926.

[4]L. V. Parisel, Jour. de Pharm., 19: 251–252. 1833.

[5]C. J. S. Thompson, Pharmaceut. Jour., (3) 17: 567. 1887.

[6]F. Czapek, Biochemie der Pflanzen, Vol. 3. 1921.

[7]W. R. Dunstan and H. Garnett, Jour. Chem. Soc. (Lond.), 67: 100–102. 1895.

crystalline principle of pellitory. They say, "It is very probable that it is the same substance as that isolated, but very imperfectly examined, by Buchheim, in 1876, and named by him *pyrethrine*." In 1896 Schneegans[8] spoke of *pyrethrin* as the active constituent of *Anacyclus pyrethrum*.

Insect powder was investigated in 1909 by Fujitani,[9] who is responsible for the first analytical work of much significance on it. He found a physiologically active ester which he called *pyrethron*. Yamamoto[10] worked with the same substance in 1918 and used Fujitani's name for it. Staudinger and Ruzicka[11] found the principle to consist of two related esters which in 1924 they called *pyrethrins* I and II. They reported that Fujitani's *pyrethron* was the same as their mixture but contained somewhat more than fifty per cent of impurities. Their action in changing an established name is hard to understand. Furthermore, the fact that their name was already in use should have been easily ascertainable from various medical and botanical reference works. In 1927, Ott and Behr[12] pointed out this use of the same name for two widely different chemical products of the respective plants and claimed *pyrethrin* for the principle in Bertram root on the basis of priority. On the other hand, Gulland and Hopton[13] proposed in 1930 to retain Dunstan and Garnett's name *pellitorine* "in preference to the earlier 'pyrethrin' in order to avoid possible confusion with the constituents of *Pyrethri flores*, the dried flowers of pyrethrum species which are used in powdered form as insecticides."

Under the circumstances it might seem obvious that the term *pyrethrin* should be retained for the active principle of pellitory and another name used for that of the insecticide. Fujitani's term *pyrethron* for the latter has priority but it has not been widely accepted and is too similar to be an improvement in nomenclature. On the other hand, pellitory is a drug of minor and waning importance, whereas extracts of pyrethrum flowers are very widely used and are becoming increasingly important as insecticides. The term *pyrethrin* for the active esters in the flowers, though originally incorrectly applied, is so generally used by plant chemists, pharmacologists and entomologists that it is neither feasible nor desirable to attempt its restoration to the original usage. However, ambiguity should be avoided by reference to its plant source.

HAROLD H. SHEPARD, *University of Minnesota, St. Paul, Minnesota*

The Honey Bees of Africa. Having before me a large collection, from nearly all parts of the Ethiopian region, I have tried to understand the taxonomic problems involved. In a recently (1929) published paper, A. S. Skorikow offers a revisionary treatment of *Apis* on a new basis. His map shows the whole of continental Africa, south of the Sahara, as occupied by *A. adansoni* Latr., while Madagascar is the home of the black *A. unicolor* Latr. Enderlein (1906) recognized from Africa a subspecies *unicolor* of *Apis mellifera* L. (*mellifica* L.), distinguished by its smaller size, the workers about 10–12 mm. long, with anterior wings 8 to 9 mm. This subspecies was divided into two groups, one with the abdomen black, the other having reddish fulvous markings as in *A. mellifera* var. *ligustica* Spinola. The black ones are again

[8]Schneegans, Abstract in Chem. Zentr., 2: 945. 1896.

[9]J. Fujitani, Archiv. f. Exp. Path. u. Pharm., 61: 47–75. 1909.

[10]B. Yamamoto, Abstract in Botanical Abst., 5, No. 840.

[11]H. Staudinger and L. Ruzicka, Helvet. Chim. Act., 7: 177–201. 1924.

[12]E. Ott and A. Behr, Ber. Deutsch. Chem. Ges., 60B: 2284–2287. 1927.

[13]J. M. Gulland and G. U. Hopton, Jour. Chem. Soc. (Lond.) (I): 6–11. 1930.

divided into those without greyish bands of tomentum on the tergites, the Madagascar *unicolor*, and those with such bands, which may have a black scutellum (var. *intermissa* Butt. Reep.), or a fulvous one (var. *friesei* Butt. Reep.). The *ligustica*-like races are *adansoni*, with yellowish hair on thorax and dark hair on vertex, and *lamarckii* Ckll. (*fasciata* Latr., preocc.), with whitish hair on thorax and few dark hairs on vertex. The latter is from Egypt, and is properly a member of the Palaearctic fauna. A careful examination of the material indicates that all the forms may properly be considered races or subspecies of *A. mellifera*, not more distinct than the African races of *Homo sapiens*. Size is variable, but it is now impossible to determine how much this may be due to crossing with European *A. mellifera*, brought over by the settlers. A worker from Aburi, Gold Coast (*L. Armstrong*) could only be referred to true *A. mellifera*, but in general the *adansoni* from all over Africa look much alike, and the climatic regions, warmer or cooler, wetter or drier, do not appreciably affect their appearance. In Rev. Zool. Bot. Afr., XXIII, p. 22, I gave a list of localities for *adansoni*. I can now add that it extends southward into South Rhodesia (*Jesse*, *J. Ogilvie*; Matopo Hills, *L. Ogilvie*); Orange Free State (Ficksburg, *L. Ogilvie*); Natal Amanzimtoti, *W. P. Cockerell*; National Park, *L. Ogilvie*); Ingogo, *A. Mackie*; Greytown, *L. Ogilvie*; Durban, *J. Ogilvie*; and the Cape Province (Port Elizabeth, *L. Ogilvie*, Camps Bay, *R. E. Turner*; Mossel Bay *R. E. Turner*; Nieuwoudtville, *L. Ogilvie*; Calvinia, *A. Mackie*). There is, however, a black form, parallel with the black honey-bee of Europe. This is what Buttel-Reepen called *intermissa*. The bands of grey tomentum are not always evident, being hidden when the abdomen is contracted. These black *intermissa* bees are common in the south, especially in the Cape Province (near Cango Caves, *J. Ogilvie*; Huguenot, *L. Ogilvie*; Graaf-Reinet, *J. Ogilvie*, Montagu Pass, *L. Ogilvie*; Doorn River, *L. Ogilvie*; Oudtshoorn, *J. Ogilvie*; Nieuwoudtville, *Cockerell*; Naauwpoort, *J. Ogilvie*); but also in Natal (National Park, *J Ogilvie*) and in the Transvaal (Kruger National Park, *J. Ogilvie*). The same insect is known from various places in East Africa, as far north as Nairobi, and it enters the drier part of the Belgian Congo (Lukulu in Katanga, *G. F. de Witte*). In a general way, it may indeed be said that true *adansoni* is characteristic of tropical Africa, and the dark *intermissa* of the drier and in part cooler regions to the south and east. But it may be possible, or probable, that the early Dutch settlers brought the European black bee, and that this has crossed with the native *adansoni*. It would perhaps now be impossible to determine whether there were any black bees in South Africa before the Europeans arrived. The extensive experiments now being carried on at Pretoria, producing crosses between *mellifera* and *adansoni* races, may throw light on this problem. However, black bees from the Kivu highlands (Tshibinda, *J. Ogilvie*, *L. Ogilvie*; south of Bukavu, *Cockerell*) have the abdomen as in the Madagascar race *unicolor*, and I do not at present see how they are to be separated from that form. The occurrence of *unicolor* in the mountains near the Equator is of much interest.

I tried to find structural characters in the venation, but although they are in some cases striking, they are not constant. Authors have attached great importance to a small character in the hind wings. At the narrowly truncate end of the mediellan cell arise two appendicular veins, one from the upper, one from the lower corner. In the Oriental form *A. indica* Fab. it is said that the vein from the lower corner is always present, whereas in the European and African races it is absent or at best represented by a minute rudiment. I have a specimen of *A. indica* from Manila. P. I. (*McGregor*) in which it is wholly absent, but very likely there has been crossing

with *A. mellifera.* In a male from Kansenia, Katanga, Belgian Congo (*de Witte*) the vein from the lower corner is quite well developed, though I find it in no other African males. I have marked this specimen *A. mellifera*, variety. In a worker of *lamarckii* I find that the vein from the lower corner is absent, but that from the upper corner is a mere rudiment. This insect has a yellow scutellum, and its distinction from the var. *cypria* Pollm., described from Cyprus, seems rather elusive. My impression is that *lamarckii* (of which I have only one specimen, from F. Smith's collection) belongs rather with the European than the Ethiopian races. The anterior wing is 9 mm. long. Taking up a male *A. mellifera ligustica* from Mesilla Park, New Mexico, I found some striking characters in the venation of the anterior wing. The third intercubitus (outer side of third cubital cell) is little flexuous (very strongly flexuous in the Kansenia male). The lower side of the third cubital cell receives the second recurrent nervure far beyond the middle (not greatly beyond middle in Kansenia male), the face of the second cubital cell on first discoidal is very short, not nearly equal to half length of first cubital cell on first discoidal (nearly equal to half in Kansenia male). These characters are so pronounced that one could believe the insects distinct species, notwithstanding their close agreement in other respects. But on examining various specimens from various places, the characters do not hold well, though the general tendency is much more toward the Kansenia than the Mesilla Park characters. Is this perhaps a result of racial crossing, and does the pure *ligustica* actually have good venational characters?

Males referred to the dark *intermissa* form have no yellow bands on the abdomen, and the hair of the scutellum is black or sooty. These come from Kinangop (*Turner*) and Nairobi. Many South African *intermissa* workers have a red band on base of second tergite (Nieuwoudtville, Graaf-Reinet, Huguenot).

T. D. A. COCKERELL, *Boulder, Colorado, July 29*

IMPORTANT NOTICE

The American Association of Economic Entomologists at the Atlantic City meeting adopted the following recommendation of the Membership Committee to: "Study the classes of membership in the Association with the idea of possibly combining the present associate and active membership, or recommending specifications more clearly defining qualifications for the present classes of membership, and submit a report at the next annual meeting."

In addition to the various obvious reasons on which there is no desire to influence anyone as to his opinion, the Membership Committee desires to point out how difficult it is to determine those eligible for transfer from associate to active membership, and that no two membership committees have used the same standards and few members have the same standards in mind in making recommendations for such transfer.

You are urgently requested to send in a discussion of your views on these two questions: (1) Do you prefer two classes of membership as at present or do you prefer one class of membership with all members on equal status; (2) In the event two classes of membership are continued, what definite qualifications do you recommend for the advancement of an associate to active membership.

IMPORTANT.—Those interested should send their remarks promptly to W. H. Larrimer, Chairman of Membership Committee, American Association of Economic Entomologists, Bureau of Entomology, U. S. Dept. of Agriculture, Washington, D. C.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

OCTOBER, 1933

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings: 1933-34 Boston; 1934-35 Pittsburgh; Summer meetings: 1933 Chicago. 1934 San Francisco

The value of an entomological paper depends in large measure upon the authenticity of the identifications. It is true that years of study and experience have made us acquainted with many insects and their variations within specific limits. This has tended to obscure somewhat the fundamental importance of correct names and yet an invesitgator must know what insects he is studying. It is not simply a question of counting hairs, ascertaining the arrangement of scales, or discovering the peculiarities of minute structures. The problem is to learn the combinations of characters which separate groups Nature recognizes as species—those which reproduce themselves and behave in the same manner under varied conditions. This is relatively easy with the larger better known insects. It is an impossible task for one to distinguish accurately between all of the multitudinous forms we know as insects. The accurate identification of most insects is and must of necessity be relegated to specialists or groups of specialists and their work, though usually done in the seclusion of a laboratory is of fundamental importance in all work in economic entomology. There is in this number one paper on parasites. These insects could be named only by specialists and without their aid, the paper would have little value. Another contribution in this issue is limited to an obscure group containing a few economic species. It could be written only by a specialist. These facts are recognized in a general way by all entomologists. It is doubtful

if many economic workers fully realize their dependence upon the tireless, careful studies of the specialists or systematists. It is well known that appropriations are much more easily obtained for investigations or studies of destructive pests in the field than for groups engaged in ascertaining criteria for the identification of the pests and their allies. It is not only essential that specialists recognize all native insects in their respective groups but they are frequently called upon to name specimens from all parts of the world. This latter is due to insects frequently being brought into the country by various commercial agencies in spite of our comprehensive and efficient quarantine service. We must have specialists for the identification of insects Let us recognize their value more fully, acknowledge our indebtedness to them freely and do all that is possible under present conditions to maintain services of this character unimpaired.

It is a long step from a Kansas farm boy to the Chiefship of the Federal Bureau of Entomology with its millions of appropriations, or the Headship of the quarantine service with approximately equal resources. This was taken, by Dr. C. L. Marlatt, who on the completion of 45 years of governmental service, a notable record of itself, has retired on account of age limitations. There is more than the mere matter of personal achievement in this record. One of the founders of the Kansas State Agricultural College, the Institution which gave Dr. Marlatt his training and presumably initial interest in entomology, was his father, and the college itself was located on a portion of the paternal acres. During this period of 45 years, Dr. Marlatt has seen the appropriations for the entomological work of the Department of Agriculture increase from approximately $50,000 annually to about $6,000,000, if we include, as should be done, the funds devoted to quarantine work as well as those for the research activities of the Bureau. He took a leading part in securing the enactment of a Federal quarantine law and administered that with a high degree of success for about 17 years, turning over this activity in 1929 to Dr. Lee A. Strong, who now succeeds him as Chief of the Bureau of Entomology. It was Dr. Marlatt who was responsible in considerable measure for the expenditure in 1927 of $10,000,000 in a gigantic experiment or demonstration in relation to the value of systematic clean-up measures for the control of the European corn borer. His was the guiding hand in the costly eradication of the Mediterranean fruit fly. The cooperation and team work between the veteran, now retired, Dr. L. O. Howard and his successor, Dr. Marlatt, extending over a period of 40 years, is noteworthy. Their combined efforts did much to build up the Federal Bureau of Entomology from a

comparatively insignificant organization to one providing unparalleled service in this country and with a literally worldwide influence. It is almost impossible to think of one of these men without the other. Dr. Howard's medical training was of great value in his widely known investigations of the relations between insects and certain diseases of man. The record of Dr. Marlatt abundantly justifies the training of earlier years in the Kansas State Agricultural College. It is one of the many admirable records made by graduates throughout the country of the relatively new land grant colleges. It is more than probable that Dr. Marlatt will continue to take an active interest in some phase of entomology. His successor, Dr. Lee A. Strong, is intimately acquainted with affairs through his four years administration of the Bureau of Plant Quarantine He is most willing to cooperate with entomologists throughout the country and is determined that the prestige of the work shall not suffer He may be assured that all entomologists gladly endorse such a program and may be counted upon for aid in its accomplishment.

Current Notes

Professor Herbert Osborn of Ohio State University has been made Professor Emeritus in Zoology and Entomology and, in conformity with provisions of the State Teachers Retirement System, retires from active teaching duties. He will continue with his research work especially on Homoptera and as Director of the Ohio Biological Survey.

Mr. A. C. Gould, Apiary Inspector of the New York Department is having markedly good results in cleaning up American foulbrood on the area cleanup plan. The area is under intensive inspection and has shown a marked reduction in disease during the past three years, and it is thought that continuous intensive inspection of these areas will not be necessary in the future.

The Research Laboratory of the Pennsylvania State College located at Arendtsville will be discontinued. This laboratory was established in 1918 for the purpose of studying fruit insect and disease problems. The laboratory will be officially closed on October 1, 1933, and S. W. Frost will be transferred to State College. This move is a result of a desire to centralize the work at The Pennsylvania State College and eliminate field stations.

Frank F. Lindstaedt, who for the past seven years has been Director of Research for the Colloidal Products Co., and Hercules Glue Co., of San Francisco has resigned that position to establish a practice as consulting chemist. He will specialize in insecticidal and colloidal chemistry. Mr. Lindstaedt's researches in the past have resulted in the discovery of several new insecticides, spray compositions and improvements in spreaders. He has opened a well equipped laboratory for conducting his future investigations and researches at 2029 46th Ave., Oakland, California.

Porto Rico, because of its similarity in climate and topography to the Island of Mauritius in the Indian Ocean, has been selected by the Imperial Institute of Ento-

mology for the collection of parasites of white grubs to send to Mauritius. Mr. W. F. Jepson arrived from England early in May, his first collections being of over 2,000 adult "cucubanos," *Pyrophorus luminosus* Illiger, the larva of which is predaceous on white grubs and on soil-inhabiting insects generally. About half of these were sent in cold storage to England, enroute for Mauritius. The others were sent by air-plane express to Barbados, arriving there three days later without a single mortality. (The white grub of Mauritius, *Phytalus smithi* Arrow, originally came from Barbados.

Mr. R. W. E. Tucker of Barbados, spent a month in Porto Rico assisting in the collection of parasites. Mr. Tucker states that a few years before he came to Barbados, as one result of an anti-malaria campaign, all pools in which the giant introduced toad, *Bufo marinus*, might breed, were filled in or drained, and in recent years the cane growers were complaining of much greater injuries in their fields due to white grubs. This is exactly the reverse of what is happening in Porto Rico, where the numbers of this recently introduced toad are becoming so great as to exert an appreciable influence on white grubs, so much so indeed that they are now much less serious pests than previous to the introduction and spread of *Bufo marinus*.

The 29th quarterly meeting of the Entomological Club of Southern California was held on September 8 at the Elks' Club, Alhambra with 76 members in attendance.

Included in the program was a discussion of the Citrus pests of South Africa by C. J. Joubert of Stellenbosch University, who is spending the year in study at the Citrus Experiment Station; the Early History of the Red and Yellow Scales in California by Harold Compere, Citrus Experiment Station; a brief discussion of the status of the Alfalfa Weevil in California by A. E. Michelbacher of the University of California, Berkeley, as an introduction to a talk by S. E. Flanders of the Citrus Experiment Station on Introducing Alfalfa Weevil into California; an elementary course in statistics entitled "What does Plus and Minus Mean?" by Wm. Moore of the American Cyanamid & Chemical Corporation.

C. I. Bliss of the Bureau of Entomology reported on the Salt Lake City Meeting of the Pacific Slope Branch, A. A. E. C., while several members reported entomological items of interest such as the wide spread injury this year to young citrus fruits in Southern California by *Platynota tinctana* Walker (E. A. MacGregor); the abundance of *Pseudococcus citri* (R) on citrus in certain districts, particularly following an oil spray program for several years (H. H. Wilcomb), an outbreak of *Tetranychus 6-maculatus* Riley in Ventura County (E. E. Smith) and the control of *Pantomorus godmani* (Crotch) by means of cryolite (A. M. Boyce).

Sailing from Puerto Rico on September 7, 1933, Mr. W. F. Jepson, of the Imperial Institute of Entomology, took with him, en route to Mauritius, about 150 giant toads, *Bufo marinus* L., about 750 female Scoliid wasps of *Elis xanthonotus* Rohwer and about 500 predaceous larvae of the "cucubano," an Elaterid beetle, *Pyrophorus luminosus* Illiger. These predators and parasites are being taken to Mauritius in an attempt to increase the natural control of the white grub, *Phytalus smithi* Arrow, an accidentally introduced pest originally coming from Barbados. It has been found that the Porto Rican Scoliid, *Elis xanthonotus*, will attack *Phytalus smithi* grubs in captivity, the larvae developing and forming cocoons apparently normal in every respect, and it is hoped that the females carried by Mr. Jepson will accept the new host when released in the field in Mauritius. The toad and the larval cucubano are not closely restricted in their choice of food, and the chances of their survival in a new but similar environment appear to be good.

On September 5th, Mr. Jepson addressed the most successful and largely attended meeting of the Entomological Society of Puerto Rico yet held. He spoke on the organization of economic entomology in the British Empire, and, as an example of how problems are handled, detailed his own experiences in the present project.

It will be of interest to all workers in biology and to nature students everywhere to learn that the Council of the Biological Society of Washington just recently has reissued all the various parts of its Proceedings formerly out of print, and can now supply a limited number of complete sets of its Proceedings, volumes 1 to 46, 1881 to 1933, inclusive, or can also supply whatever parts may be needed to complete partial sets now in the libraries of individuals or institutions. Among the items again available is the formerly very rare Volume 3, July 1, 1884 to February 6, 1886, now lacking from a considerable number of otherwise complete sets. This volume contains, pages 35 to 105, inclusive, the well known work by Dr. G. Brown Goode entitled "The Beginnings of Natural History in America," the continuous demand for which contributed to the speedy exhaustion of the original edition. Lists of desiderata or requests for information should be sent to the Society's Corresponding Secretary, J. S. Wade, U. S. Bureau of Entomology, Washington, D. C.

Mr. E. Graywood Smyth, entomologist for the W. R. Grace & Company sugar estates in South America, has recently returned to Hacienda Cartavio, Peru, from an extended vacation in the States. He visited New York, Chicago, various points in the Middle West and in California, and made a special study of the latest methods being utilized in the propagation of Trichogramma. Because of the benefits to plantation cane that have resulted from three years of mass breeding and liberation of Trichogramma conducted by him in Peru, the Hacienda Cartavio has recently multiplied its facilities for the production of the egg parasite by increasing the moth rearing houses (built on the Hinds-Spencer plan) from two to six units, and it is aimed to turn out over thirty million wasps during the coming season.

Horticultural Inspection Notes

The annual Japanese beetle quarantine conference will be held in Washington, D. C., on October 24, and a conference to discuss possible modifications in the foreign nursery stock quarantine will be held on the following day.

In Circular BPQ-354, the Bureau of Plant Quarantine has modified the conditions of entry of narcissus bulbs. Hereafter, instead of requiring the hot water treatment of all such bulbs, only the shipments found infested at the port of entry will be treated and the nature of the treatment will depend on the pest found.

Messrs. G. M. Bentley of Tennessee and R. W. Leiby of North Carolina attended the August 30 and 31 meetings of the Southern Nurserymens Association at Jacksonville Beach, Fla. Dr. Leiby gave an illustrated talk on the Japanese beetle. He also invited the association to meet in Asheville, N. C., next year and the invitation was accepted.

A modification of the Kansas quarantine relating to the European corn borer, excludes from the list of restricted articles celery, oat and rye straw, cosmos, zinnia and hollyhock, and excludes Ohio, Michigan, and Indiana from the regulated areas so far as the restrictions with reference to other floral and vegetable host plants are concerned. This modification became effective on July 1.

Mr. L. M. Ames of the Federal Bureaus of Plant Industry and Plant Quarantine has been engaged during the past two months in checking on nurseries which grow barberry and Mahonia plants. Under a Federal quarantine, rust-susceptible barberries are not permitted to be shipped to the principal grain-growing States, and barberry-growing nurseries are checked to see that only rust-resistant species are grown.

The American Phytopathological Society at its June meeting appointed a committee to discuss the biological basis of plant quarantines with a similar committee of entomologists. Dr. L. R. Jones, Madison, Wis., is chairman of the committee of phytopathologists, and Dr. W. C. O'Kane, Durham, N. H., chairman for the committee from the American Association of Economic Entomologists.

A quarantine relating to the two-generation strain of the European corn borer was placed by the Michigan State Commissioner of Agriculture on June 19, under which the host plants are required to be processed or certified when shipped from the New England States, New Jersey, New York, Pennsylvania, or Virginia. No restrictions are placed on beans, beets, rhubarb or young floral plants or cut flowers of gladiolus during the period from January 1 to June 1.

The administration of the State Crop Reporting Service in Arkansas and of the Pure Seed Law was transferred from the Department of Mines, Manufactures and Agriculture to the Plant Board by a recent act of the legislature. The transfer became effective March 1. By the same Act the administration of the Apiary Inspection Law was transferred from the Apiary Board to the Plant Board. The Board appointed J. V. Ormond, Apiary Inspector, without pay, no appropriation having been made by the Legislature.

At the request of the Eastern Plant Board, the Bureau of Plant Quarantine recently called a conference to discuss possible State quarantine action on the European pine shoot moth (*Rhyacionia buoliana*). This was held at New Haven, Conn., on September 19. During the conference there was a field trip to observe the damage this insect is causing in Scotch pine and red pine reforestation projects in Connecticut. Representatives of Connecticut, New York, Vermont, Massachusetts, and Penna., and of the United States Department of Agriculture were present. A committee to work out specific recommendations for the Eastern Plant Board was appointed.

The annual fall conference of the Federal gipsy moth inspectors was held at Greenfield, Mass., on September 18. In addition to the usual items under discussion, the new joint certification plan, under which Federal certificates covering the Japanese beetle and white pine blister rust quarantines as well as the gipsy moth regulations are issued to New England nurseries largely by the gipsy moth inspectors, was covered in detail.

The Federal Public Works Administration has allotted approximately the following amounts for insect and plant disease suppression: $2,000,000 for gipsy moth work in Pennsylvania and also between the Connecticut River and the "barrier zone" in Connecticut, Massachusetts and Vermont; $80,000 for scouting and eradication of the Dutch elm disease in New York and New Jersey; and $2,000,000 for white pine blister rust suppression. These funds are in addition to the assignment of certain men from the Civilian Conservation Corps to the same or similar projects.

On September 15, the Federal Department of Agriculture held a public hearing at which consideration was given to the advisability of issuing a special quarantine against the importation of elm trees and parts thereof on account of the Dutch elm disease. Elm nursery stock has not been imported for several years on account of this disease in Europe, and the principal subject of discussion at the hearing related to the importation of elm logs and "burls." A number of companies manufacturing veneer from such burls were represented, and possible methods of disinfecting the logs were discussed.

Regulations relating to the phony peach disease, applying to both intrastate and interstate shipments, were recently placed by the States of Tennessee and Oklahoma. Provision is made under the Tennessee quarantine (as revised effective September 1) for the acceptance under permit of shipments of the host plants when grown in a disease-free county or disease-free environs within a mile of the planting, and when determined by tree-to-tree inspection to be free from the peach root borer. The Oklahoma rule, adopted in July, provides for the acceptance of the host plants under any one of the same conditions. The regulated area as designated under the Tennessee quarantine covers 8 entire southern States including Florida and Texas; also 8 counties in Illinois, 6 in North Carolina and one each in Oklahoma and Missouri. The Oklahoma rule does not designate the infested areas but apparently applies to shipments from any State.

The number of trees infected with the Dutch elm disease in New Jersey and New York was reported by the Bureau of Plant Industry to have reached about 398 in New Jersey and 15 in New York by September 15. The center of the infection is in Essex County, N. J., with a few trees showing the disease as far west as Bound Brook and New Brunswick, N. J., and as far east as White Plains, Rye, Port Washington and Lynbrook, N. Y. Mr. R. Kent Beattie of that Bureau stated at the annual Shade Tree Conference held in New York City on September 8 that apparently the disease had entered this country on elm logs and "burls" from Europe, and was being disseminated by bark beetles. A number of such logs infected with *Graphium ulmi*, the causal organism, and infested with *Scolytus scolytus* have recently been intercepted at various ports and treated. The species apparently responsible for the spread of the disease in New Jersey and New York is said to be *S. multistriatus*, a European form which is established in this country over the area approximately from Boston to Philadelphia.

The Lower Rio Grande Valley of Texas suffered severely from the hurricane of September 4 and 5. From 90% to 95% of the citrus fruit is reported to have been blown from the trees. Mr. L. A. Strong, Chief of the Federal Bureau of Plant Quarantine, visited the area about September 14, to consult with Mr. P. A. Hoidale and the local growers as to methods of disposing of the fallen fruit to prevent Mexican fruit flies from reaching it and breeding there. Considerable damage was done to the railway car fumigation house operated by the Bureau at Brownsville, Texas. The roof of the house was blown clear away, the walls cracked and the large end doors were badly twisted out of shape. Records and supplies stored in a room adjoining the fumigation chambers were destroyed or badly damaged. Fortunately, none of the inspectors stationed at Brownsville and other lower valley ports suffered any personal injury, although the residence of one was badly damaged.

Changes in Washington State quarantines made in July include the following: (1) The Colorado potato beetle quarantine was revoked for the reasons, according to the notice, that the insect is now generally established in many localities in the State and that its presence in shipments of potatoes can be readily detected by inspection; (2) The territory involved under the cherry fruit fly quarantine is now extended to include Idaho with two counties designated as infested, while the number of *uninfested* counties in Oregon has been increased from 5 to 11. In Washington they number 21 and part of another; (3) The quarantine relating to the downy mildew of hops now includes as infected territory those counties in Washington west of the Cascades. The embargo now applies to intrastate movement and remains in effect as to shipments from Oregon and British Columbia into uninfected territory; (4) Provision was made under the potato tuber moth quarantine for the acceptance of certificates based either on inspection or fumigation. Formerly fumigation was the only condition of certification; (5) Quarantine No. 11 relating to the Oriental fruit moth, No. 17 relating to the strawberry root weevils and crown and cane gall of berry plants, and No. 18 relating to the European corn borer, were all reissued on July 11, apparently without modification, over the signature of the present Director of Agriculture, Walter J. Robinson.

Recent changes in California quarantines include the issuance, effective August 23, of Proclamation No. 3 pertaining to the Oriental fruit moth, which supersedes Quarantine Order No. 3. Under the new proclamation "provision has been made whereby budwood or scions of new varieties of the host fruits covered may be brought into California from the quarantined area under proper safeguards, thus permitting California growers to secure certain new desirable varieties of fruit trees which have recently been developed in the eastern United States." Missouri and Kansas have been added to the quarantined areas. Quarantine Proclamation No. 11, effective August 23, supersedes Quarantine Circular No. 1 and "is intended to cover the subject of peach diseases and includes little peach as well as peach rosette and peach yellows. The only change in the quarantine area from that shown in Quarantine Circular No. 1 is the addition of the State of Illinois, while the host list has been increased to now include apricot, almond and plum as well as peach and nectarine. This increase in both the quarantine area and in the host list has been based on advice received from the U. S. Bureau of Plant Industry." The California Bureau of Plant Quarantine has also issued a circular to County Agricultural Commissioners, regarding border quarantine inspection policy "in order that there may be uniform action in the disposition of plants and plant products passing through border stations so far as inspection by the County Agricultural Commissioner at destination is concerned."

JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 26 DECEMBER, 1933 No. 6

Eighteenth Annual Meeting of the Pacific Slope Branch, American Association of Economic Entomologists

The 18th annual meeting of the Pacific Slope Branch was held at Utah State University, Salt Lake City, Utah, June 14 and 15. The meeting was called to order at 9:30 A. M. June 14. Papers were presented during the morning of the 14th and during the morning and afternoon of the 15th.

On the afternoon of the 14th, the visiting entomologists were conducted on a field trip under the leadership of Geo. I. Reeves and his assistants. The work on the alfalfa weevil was demonstrated.

The annual entomologists dinner was held on the evening of the 14th at the Temple Square Hotel.

The total attendance at the Salt Lake City meetings numbered 46, among which were the following members:

C. I. Bliss
L. D. Christenson
E. W. Davis
Louis G. Davis
R. A. Fulton
Chas. F. Henderson
Melvin J. Janes
Chas. R. Jones
Geo. F. Knowlton
Russell S. Lehman
Geo. M. List
G. Allen Mail
J. H. Newton
J. R. Parker
H. J. Quayle
Geo. I. Reeves
R. G. Richmond
H. A. Scullen
W. A. Shands
W. E. Shull
C. J. Sorenson
A. F. Swain
O. H. Swezey
R. L. Webster

PART I BUSINESS MEETING

On Wednesday, June 14, the following committees were appointed:

Nominating committee: O. H. Swezey, C. R. Jones and J. H. Newton.

Resolutions committee: H. J. Quayle, W. E. Shull and J. R. Parker.

Auditing committee: C. I. Bliss, Russell S. Lehman.

Dr. C. I. Bliss gave an extended report with recommendations concerning the publication of the Journal of Economic Entomology. The

report was submitted by a committee appointed by former president Roy E. Campbell. After some discussion it was moved, seconded and carried that the report be considered as a special item of business during the Thursday program.

At the close of the program of papers June 15, the following business was transacted:

It was moved, seconded and carried that:

1. A committee be appointed to circularize the membership of the Pacific Slope Branch to determine the attitude in regard to suggested changes in the editing and make-up of the Journal of Economic Entomology;
2. This committee prepare a digest of the views of members obtained by the above method, which shall be forwarded at the earliest date possible to the Special Committee on Policy of the Journal of Economic Entomology.

The following committee was appointed by President Webster to carry out the above motion: H. J. Quayle, C. I. Bliss and E. M. List.

The auditing Committee reported favorably on the following financial statement of the Treasurer:

Balance on hand June 16, 1932		$20.27
Interest		.35
Refund from parent society for 1932 meetings (received June 11, 1933)		9.81
Cash paid out:		
Postage and envelopes	$12.92	
Telegram	2.27	
Labor (addressing letters)	4.25	
Mimeographing	3.58	
Balance on hand June 16, 1933	$ 7.41	
	$30.43	$30.43

The committee's report was accepted.

The Resolutions Committee reported as follows:

Be it Resolved, That this Association express through its Secretary its appreciation to:

1. The University of Utah for providing rooms in which these meetings have been held; and for other courtesies which have been extended;

2. To Mr. George I. Reeves and his assistants for their untiring efforts in making local arrangements for meetings, field trips and the entomologists dinner.

Respectfully submitted,

J. R. Parker
H. J. Quayle
W. E. Shull

The committee's report was accepted.

The Nominating Committee submitted the following nominations:

President—G. I. Reeves
Vice-President—W. B. Herms
Secretary-Treasurer—H. A. Scullen

The committee's report was accepted and the officers duly elected.

It was announced that the 1934 meetings would be held at Berkeley, California.

PART II PAPERS

LIZARDS AS PREDATORS OF THE BEET LEAFHOPPER[1]

By G. F. Knowlton[2] and M. J. Janes[3]

Abstract

In Utah during the past three years, 2659 lizards have been collected and their stomachs examined. Of 1573 *Uta stansburiana stansburiana* taken among host plants of the beet leafhopper, 915 stomachs contained a total of 9322 specimens of *Eutettix tenellus* (Baker). Of 213 *Sceloporus graciosus graciosus* taken among host plants of *tenellus*, 59 stomachs contained 239 specimens of this pest. Other lizard species in which one or more specimens of *tenellus* were found include *S. elongatus*, *Phrynosoma douglassii ornatissimum*, *P. platyrhinos*, and *Eumeces skiltonianus*.

The desert lizards of northern Utah appear to be largely entomophagous, catching and devouring large numbers of insects of various kinds and sizes. As a rule, a number of insects were contained in each stomach after feeding had occurred. As might have been expected, the lizards did not discriminate between injurious and beneficial insects. Some ladybird beetles, predacious bugs, parasitic Diptera, and parasitic Hymenoptera were taken, but by far the greatest numbers were injurious or non-beneficial forms. In general, the larger lizards more commonly fed upon larger insects, while smaller lizard species and immature individuals of larger species fed more extensively upon the smaller insects.

In the northern Utah desert breeding grounds of this insect pest, several species of lizards fed upon the beet leafhopper, *Eutettix tenellus* (Baker). The most abundant and important lizard predator of this insect was the brown-shouldered Uta. This tiny lizard seems to take the

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station, in cooperation with the U. S. Bureau of Entomology.

[2]Associate Entomologist, Utah Agricultural Experiment Station, and Collaborator, U. S. Bureau of Entomology.

[3]Field Assistant, U. S. Bureau of Entomology, and Graduate Assistant, Utah Agricultural Experiment Station. Publication authorized by Director, May 22, 1933.

most readily available food during most of the season. When beet leafhoppers become more abundant in the fall, these lizards were frequently found under the plants most heavily infested. The importance of this lizard is more fully appreciated when it is realized that the stomach contents of a lizard seldom represents an entire day's feeding. It was found that 75 per cent of the nymphal and 35 per cent of the adult *tenellus* were digested beyond recognition within six hours; at the end of 24 hours, 90 per cent of the adults were likewise indistinguishable.

The method employed in collecting lizards for food-habit studies was to shoot them with a .22 rifle, using shot shells. The lizards were then labeled and placed in a 70 per cent alcohol solution, the stomach contents being examined microscopically when opportunity afforded.

The writers are indebted to Dr. P. N. Annand of the U. S. Bureau of Entomology, in charge of the cooperative beet leafhopper investigation, for suggestions and encouragement during the course of this study.

Uta stansburiana stansburiana (B. and G.). During the season March 1930 to April 1933, inclusive, 1746 specimens of the brown-shouldered *Uta* were collected, mostly in Russian thistle areas or among shadscale, sagebrush, or greasewood. Of 1573 stomachs examined from lizards taken among beet leafhopper host plants, 915 contained one or more *tenellus* (Table 1). The total number of *tenellus* recovered was 9322, representing an average of 10.1 beet leafhoppers per stomach. Heaviest feeding on the beet leafhopper occurred during late summer and fall, the peak being reached in October.

TABLE 1. SEASONAL IMPORTANCE OF *Uta stansburiana stansburiana* AS A PREDATOR OF *Eutettix tenellus* IN AREAS SUPPORTING COMMON HOST PLANTS OF THE BEET LEAFHOPPER—MARCH, 1930 APRIL, 1933—INCLUSIVE

Month	Total No. lizards taken	No. lizards containing *E. tenellus*	No. *E. tenellus* contained Adults	Nymphs	Total	Average *E. tenellus* per stomach
March	9	2	2	0	2	1.0
April	19	2	2	0	2	1.0
May	20	3	4	0	4	1.3
June	31	3	5	1	6	2.0
July	56	14	24	5	29	2.0
August	349	158	671	216	887	5.6
September	694	348	859	2451	3310	9.5
October	384	377	578	4462	5040	13.3
November	11	8	22	20	42	5.2
Totals	1573	915	2167	7155	9322	10.1

Early-season feeding was represented only by adults of *tenellus*. A nymph was first found in a stomach in June, after which time the ratio of nymphs to adults gradually changed, until during September and October nymphs greatly outnumbered adults in the stomach contents. The

number of adults and nymphs consumed was about equal during November.

In several instances individual stomachs contained unusually large numbers of *tenellus*. One lizard collected among Russian thistle in Skull Valley 1.25 miles south Iosepa on October 8, 1932, contained 17 adults and 94 nymphs, a total of 111; another lizard taken at the same time contained 4 adults and 102 nymphs. Several stomachs were examined, each of which contained more than 75 *tenellus*.

The second most abundant species of insect taken by the lizards was *Geocoris decoratus* Uhl.; 386 stomachs contained one or more of this form; the total number of individuals of this species was 1046. Ants were third in importance as a source of food; 255 Uta stomachs contained 1038 specimens.

The insect content by orders in these lizard stomachs was as follows: Collembola, 296 specimens; Orthoptera, 131; Isoptera, 157; Odonata, 16; Neuroptera, 40; Thysanoptera, 12; Homoptera, 9829; Hemiptera, 2266; Coleoptera, 425; Diptera, 731; Lepidoptera, 418; Hymenoptera, 1474 specimens. Other contents were: Spiders, 370; mites, 201; lizards, 1 *Sceloporus graciosus graciosus;* round worms, 1; bird feathers, 2; and pebbles and plant fragments. In the spring, succulent plant material was sometimes taken. During summer and fall, practically all of the plant material was dry and apparently ingested by accident, as seems to have been the case with the sand, small pebbles, and the bird feathers.

Ants were found in greatest abundance in the stomachs of the 173 Utas collected in areas not supporting common host plants of *tenellus*. Stomachs of 52 such lizards contained a total of 268 ants. Locustidae was next; 25 stomachs contained 27 specimens. The insect content by orders for these 173 lizard stomachs was as follows: Collembola, 81 specimens; Orthoptera, 32; Odonata, 1; Neuroptera, 4; Homoptera, 104; Hemiptera, 62; Coleoptera, 57; Diptera, 35; Lepidoptera, 63; Hymenoptera, 324. Other contents were: Spiders, 23; mites, 2; scorpions, 1; and sand and plant fragments.

DIGESTION STUDIES. Of 293 *tenellus* nymphs fed to 58 lizards, 75 per cent were digested beyond recognition at the end of 6 hours, 96 per cent at the expiration of 12 hours, and only one nymph was recovered from a stomach where digestion had progressed beyond the 12-hour period. Six hundred and thirty-eight adult *tenellus* were fed to 91 Utas; of these, 34.1 per cent were no longer recognizable at the end of 6 hours, 81.0 at 12 hours, 89.3 at 24 hours, and 92.7 per cent were digested at the end of 48 hours.

PARASITISM OF INGESTED BEET LEAFHOPPERS. Dissection of 1870 *Eutettix tenellus* taken from stomachs of lizards collected mostly during October, 1932, showed that internal parasitism of these leafhoppers was no greater than that of *tenellus* collected in sweepings. Two *Pipunculus* parasites were found in the 168 adult leafhoppers dissected, and only 1 *Pipunculus* was taken from 1702 nymphal *tenellus*. The average percentage of parasitism in 3067 *tenellus* collected during October of 1932 in sweepings and by dissection was 1.46 per cent.

The brown-shouldered Uta is present in considerable abundance in most desert breeding areas of the beet leafhopper in northern Utah. Upon at least three occasions, when conditions for collecting were especially favorable, it was possible in one hour for one collector to take from 75 to 100 specimens of this tiny lizard.

Sceloporus graciosus graciosus (B. and G.). Seven hundred and twenty-six specimens of the sagebrush swift were collected from areas supporting Russian thistle, sagebrush, rabbitbrush, or greasewood

Of these lizards, 213 were taken among common host plants of the beet leafhopper and 59 of the stomachs contained one or more *tenellus*. Total *tenellus* content was 239 specimens, representing an average of 4 per stomach. Ants constituted the most common source of food of lizards collected among beet leafhopper host plants; 127 stomachs contained 506 ants; Locustidae was third in order; 58 stomachs contained 64 specimens.

The insect content by orders for these 213 lizard stomachs was as follows: Orthoptera, 67; Isoptera, 1; Odonata, 1; Neuroptera, 1; Thysanoptera, 1; Homoptera, 305; Hemiptera, 176; Coleoptera, 101; Diptera, 25; Lepidoptera, 257; Hymenoptera, 651. Other contents were. Spiders, 49; scorpions, 1; and sand and plant fragments.

Five hundred and thirteen sagebrush swifts were collected in areas not supporting common host plants of *tenellus*, although an occasional stomach was found to contain a beet leafhopper. Ants were most abundant in the stomachs of these lizards; 200 stomachs contained 1248 ants. Locustidae was next most abundant; 170 stomachs contained 216 individuals.

A summary of the insect content by orders for these 513 lizard stomachs follows: Collembola, 2; Orthoptera, 219; Isoptera, 88; Neuroptera, 16; Thysanoptera, 1; Homoptera, 414; Hemiptera, 121; Coleoptera, 313; Diptera, 162; Lepidoptera, 218; Hymenoptera, 1465. Other contents were: Spiders, 32; scorpions, 1; round worms, 40; symphylids, 1; and sand and plant fragments.

The sagebrush swift was the second most abundant and important lizard predator of *Eutettix tenellus*. This predator also fed quite extensively on grasshoppers.

Sceloporus elongatus Stejneger. During 1932 two half-grown specimens of *Sceloporus elongatus* were collected among Russian thistle in the Uintah Basin in northeastern Utah; one contained an adult and the other a nymphal *tenellus*. No beet leafhoppers were found in the stomachs of twelve additional specimens taken among sagebrush and rabbitbrush.

Phrynosoma douglassii ornatissimum (Girard). Girard's short-horned toad was collected principally among greasewood, Russian thistle, and sagebrush. Twenty-four specimens were taken; one specimen collected 3.5 miles east of Cedar Creek, Boxelder County, on September 7, 1931, contained an adult *Eutettix tenellus*.

Phrynosoma platyrhinos Girard. Sixteen specimens of the desert-horned-toad were collected, principally from areas supporting Russian thistle, sagebrush, and shadscale. A specimen taken at Bovine Point in Boxelder County, on August 11, 1931, among shadscale, contained an adult *Eutettix tenellus*. Two specimens collected 2 miles east of Promontory, Boxelder County, on September, 1931, contained 1 nymphal and 1 adult *tenellus*, respectively. As predators of the beet leafhopper, horned toads appear to be of little importance

Eumeces skiltonianus (B. and G.) One specimen of the western or Skilton's skink was taken in the foothills 3.5 miles west of Clover, Tooele County, on August 31, 1932. This lizard contained an adult *Euttetix tenellus*, probably taken upon a nearby plant of *Verbena bracteosa*.

Crotaphytus wislizenii Baird and Girard. Seventy-two specimens of the leopard lizard were collected; most of these were taken in Skull Valley among sagebrush, rabbitbrush, and junipers. Although a number of juvenile specimens of lizards were collected among host plants of the beet leafhopper, no *tenellus* were found in their stomachs.

Uta levis Stejneger. The Rocky Mountain tree Uta was collected in Uintah Basin, in northeastern Utah. Two specimens were collected among sagebrush and two among sagebrush and Russian thistle; beet leafhoppers were not found in the stomachs of these specimens.

Sceloporus occidentalis biseriatus (Hallowell). One specimen of the western blue-bellied lizard was collected 3 miles south of Iosepa in Skull Valley, Tooele County, in 1932, among redscale, *Atriplex rosea; Eutettix tenellus* was not found in its stomach.

Cnemidophorus tessellatus tessellatus (Say). Seventy-nine desert whiptail lizards were collected, principally from areas supporting sagebrush,

junipers, rabbitbrush, greasewood, and Russian thistle. No beet leafhoppers were found in the stomachs of these lizards.

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INSECT TOLERANCE

By R. L. WEBSTER, *Washington Experiment Station**

ABSTRACT

Reference is made to previous studies on the subject of resistance to insecticides with special reference to the San Jose scale (*Aspidiotus perniciosus*), the red (*Chrysomphalus aurantii*) and black (*Saissettia oleae*) scales of California, and to resistant strains of codling moth (*Carpocapsa pomonella*). In the field laboratory at Wenatchee, apples were sprayed with the oil-lead arsenate combination and a uniform deposit of between 60 and 65 micrograms arsenic per square inch of apple surface obtained. In 1930 an average control of 73.0 per cent was obtained. This dropped to 60.0 per cent in 1931, and to 36.0 per cent in 1932.

In a paper presented by Dr. A. L. Melander at the Atlanta meeting of the American Association of Economic Entomologists, evidence was presented which indicated that the San Jose scale at Clarkston, Washington, was more difficult to kill with concentrations of lime-sulphur which were effective elsewhere in the Pacific Northwest (1). It was inferred at that time that this scale insect had acquired certain resistance to lime-sulphur in this particular area and that such resistance had developed since 1902, at which time Piper's study of the effectiveness of lime-sulphur was conducted at Wawawai, Washington.

RESISTANCE TO LIME-SULPHUR IN WASHINGTON.—The two locations mentioned are on the Snake River in Washington, the last named about 16 miles from Pullman, the first, where most of Melander's work was conducted, about 34 miles from Pullman. Because of the bends of the river, the two locations are probably some 30 miles apart. Climatic conditions in the Snake River Canyon, which is some 2000 feet below the surface of the surrounding country, are, by reason of higher average temperatures, well adapted for raising fruit. The altitude at Clarkston is 757 feet, at Wawawai, 658 feet, and at Pullman, 2,500 feet.

In this first paper Melander showed that, while a 5 degree lime-sulphur resulted in 100 per cent control at Yakima and at Sunnyside, with this

*Published as Scientific Paper No. 265, College of Agriculture and Experiment Station, State College of Washington.

same treatment at Clarkston 8 per cent of the scale was still alive six weeks after treatment. Where a 3 degree lime-sulphur was used, no living scale was found at Yakima, one-half of one per cent at Sunnyside, and 13 per cent at Clarkston. When the concentration was cut down to 2 degrees Baumé, no living scale was found at Sunnyside, one-half of one per cent at Yakima, and 17 per cent at Clarkston.

Again in 1915 Melander reported further evidence of tolerance, based on investigations conducted in 1914 (2). While the San Jose scale was easily controlled with a 2, 3, or 5 degree lime-sulphur at Wenatchee, the control was somewhat less satisfactory at Yakima, more so at Walla Walla, and most unsatisfactory at Clarkston. In this series of experiments, a lime-sulphur concentrate, made at Clarkston and testing 34 degrees Baumé, was used and diluted accordingly.

Lime-sulphur has been used at Walla Walla probably as long as anywhere in the Northwest, and the 1914 studies showed that 55 days after spraying with a 5 degree lime-sulphur, 34 per cent of the scale was alive. At Clarkston, 50 days after spraying with 5 degree lime-sulphur, 39 per cent of the scale was alive.

Finally, in 1923, Melander reported on a 12-year study of the problem, his investigation dating back to experimental spraying in Clarkston in 1908 (4). At this time he pointed out that while "the scale in the lower Clarkston flats has throughout the investigation manifested an astounding resistance to polysulfide sprays . . . this resistance had reached its apparent maximum by the time this investigation was begun."

Control of San Jose Scale in Illinois.—Further evidence on the subject of resistance is offered by the failure of lime-sulphur to check San Jose scale in southern Illinois, as reported by Flint. (5) In this case a loss of over 1,000 acres of apple trees in southern Illinois during the period 1920–1922 was indicated. These trees had been treated annually with 32° Baumé lime-sulphur, one gallon to eight gallons of water. At Olney, 47 days after spraying, there was 11 per cent living scale.

It may be recalled that it was in another county of southern Illinois, farther west and across the state, that the experiments of Titus in 1902 first showed conclusively that lime-sulphur could be used in the eastern United States and result in effective scale control.

Resistant Red and Black Scale in California.—In August, 1919, Professor H. J. Quayle showed me resistant red scale, *Chrysomphalus aurantii*, at Corona, in southern California, which was at that time only just beginning to be recognized as such. In this instance lemon trees had been fumigated with heavy doses of cyanide, sufficient to injure foliage severely, and yet the red scale was not entirely killed.

Later, in 1922, Quayle (3) published a preliminary statement in which he pointed out that the red scale was more resistant to fumigation in Orange County and at Corona than elsewhere in California. In the same paper Quayle showed that the black scale, *Saissetia oleae*, in the Charter Oak district, was also becoming resistant to fumigation with hydrogen cyanide.

Woglum (6) further pointed out that both these scale insects had developed some degree of resistance but that the areas in which this resistance occurred were different in the two cases. He advanced the belief that the resistant red scale originated at Corona and the resistant black scale at Charter Oak. The two areas are separated from each other by a chain of hills.

In the period between 1907 and 1909 the red scale was not difficult to control with what was then known as the 75 per cent schedule, according to Woglum. In 1918 and later, the red scale became impossible to control in the resistant area, even in the same orchards, and with twice the dosage of cyanide fumigation.

Resistance of Codling Moth to Arsenical Poisons.—More applications during the season, increasing amounts of spray material, and a greater number of gallons per tree is the history of spraying practice for codling moth control in the Pacific Northwest. During the past seven or eight years fruit growers in the heart of the Wenatchee district have gone from a schedule of five cover sprays to one of six covers. They have increased the dosage of lead arsenate from two pounds to 100 gallons to three pounds and have applied even greater amounts of spray material. It is now common practice to use 25 or 30 gallons at each cover spray to larger trees on which a grower may expect to produce from 25 to 30 boxes of apples.

Losses from codling moth were more severe in 1932 in the Northwest than for many years. The previous year had been considered as one in which the insect had been difficult to control, but in 1932 undoubtedly the situation was far worse. Moth activity late in the season and the heavy carry-over of worms from the previous year are generally considered as being responsible for the unusual amount of wormy fruit. Another factor, more difficult to estimate, was in the attempt of the grower to economize on spray materials, due to general prevailing economic conditions. All these factors, however, do not seem adequate to explain the lack of control generally experienced by apple growers in the Northwest in 1932, especially in the Yakima and Wenatchee valleys.

That the codling moth may be gradually acquiring a resistance to spray materials is a notion advanced in recent years, with some little

evidence in this direction. Control of the insect has been especially difficult in the Grand Valley in Colorado, as well as in the Pacific Northwest. The investigations of Dr. W. S. Hough, who found that worms originating in Colorado were far more difficult to poison than those from Virginia, first gave evidence for such a belief so far as the codling moth is concerned (7 and 8). Hough also found that worms from the Yakima Valley were intermediate between the other two. Placed on sprayed

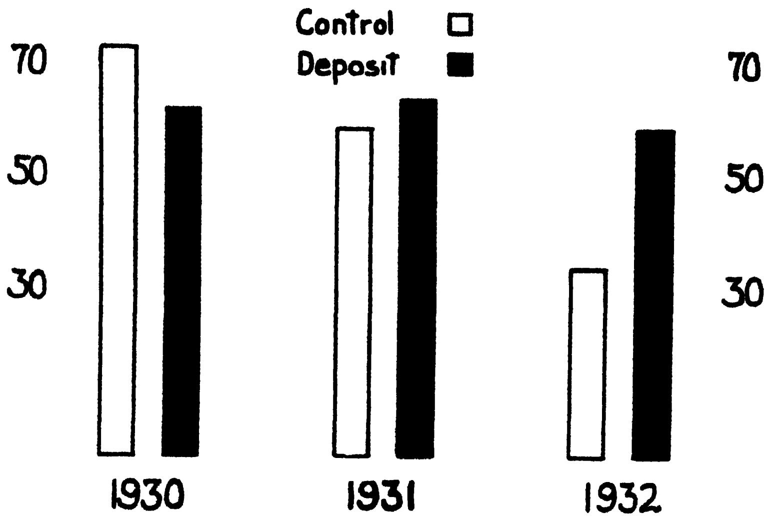

FIG. 84.—Control in laboratory with oil-lead combination.

apples in the laboratory. it was determined that while the lead arsenate permitted 15.5 per cent of the Virginia worms to enter, 33.2 per cent of the Washington worms made their way into the apples, while 51.5 per cent of the Colorado worms gained entrance. Both worms and stings were considered as entries in this study.

A comparison of three years of laboratory studies at Wenatchee in which the oil-lead arsenate combination was sprayed on apples indicates a decreasing effectiveness in lead arsenate in stopping the entering worms. In these tests, as reported by Webster et al, (9) the oil-lead arsenate was sprayed on apples in the laboratory and codling moth eggs in the "blackhead" stage were placed thereon immediately. There was no effect of the mineral oil, since the eggs, deposited on waxed paper, were pinned to the apples after the spray application. Such a test measures only the larvicidal value of any spray treatment. The same brand of lead arsenate was used throughout at the rate of two pounds per 100 gallons, to which was added one gallon of summer oil emulsion.

This is the usual oil-lead arsenate combination of the Pacific Northwest, especially valuable in the orchard during the early cover sprays and at the height of egg deposition.

At the time that the apples were sprayed, duplicate samples were turned over to C. D. Dolman, industrial chemist employed by the Wenatchee Valley Traffic Association, for analysis of the arsenical deposit. These analyses showed a uniform amount of arsenic during the three years, running between 60 and 65 micrograms per square inch of apple surface. With a film type of coverage, this has generally been considered as sufficient to stop most of the worms.

In 1930 an average control of 73.0 per cent was obtained, according to tests conducted by one of our graduate students, Mr. Thomas P. Strand. This dropped down to 60.0 per cent in 1931, according to results obtained by Kenneth D. J. Gillies, another graduate student, and to 36.0 per cent in 1932, when this series of experiments was carried out by Cecil E. Miller, graduate student employed on a Crop Protection Institute Fellowship.

Figure 84 indicates the difference in control in the laboratory during the three years with the oil-lead arsenate combination. In its consideration, it should be borne in mind that two most important field variables, i.e., moth population and variations in spray practices, are eliminated.

TABLE 1. THREE YEARS' LARVICIDAL TESTS WITH LEAD ARSENATE

Year	Treatment	Larvae used	% control
1930	All brands Lead Arsenate—2 lbs.-100 gallons	825	56.06
1931	Corona Lead Arsenate—2 lbs.-100 gallons	664	52.3
1932	Corona Lead Arsenate—3 lbs.-100 gallons	798	40.8

Similar results were obtained in the laboratory at Wenatchee when lead arsenate was applied without mineral oil. Since the 1930 and 1931 trials were on the basis of two pounds of the arsenical to 100 gallons of water, and the 1932 tests at 3–100, the comparison is not direct, yet the same trend is evident, even with a greater concentration in 1932.

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DETECTION AND DETERMINATION OF SURFACE OIL ON CITRUS FOLLOWING SPRAYING[1]

By A. F. SWAIN and DON GREEN, *the Pacific R & H Chemical Corporation, El Monte, California*

ABSTRACT

Factors involved in the study of oil spray application are set forth, and methods available for such study are reviewed. Two new techniques are presented; one for the determination of extent of coverage by the use of an adherent powder, the other for the determination of surface oil films by means of a solvent wash. Illustrations of the range of application of the two techniques are given.

The use of petroleum oils as insecticides for the control of scale insects attacking citrus is based on the theory that the oils act as contact insecticides. If this be true, it follows that the effectiveness of any commercial treatment with petroleum oil depends not only on the degree of contact obtained, but also on the length of time during which such contact continues. In terms of application of the insecticide to the host plant, this means that coverage not only should be complete as regards amount of surface covered and quantity of oil deposited, but also should be of sufficient permanence to secure the desired results.

A proper and complete study of petroleum oil insecticides in relation to the effectiveness of application should include, therefore, information on the following factors:

1. Extent of coverage.
2. Quantity of oil deposited per unit area.
3. Disposition of oil after application.

Although a number of investigations have been in progress recently bearing on various aspects of the problem as a whole, no method has heretofore been published for the direct determination of the extent of

[1]Contributions from the Research Laboratories of The R & H Chemicals Department of E. I. du Pont de Nemours & Co. Inc., and the Pacific R & H Chemical Corporation.

coverage obtained with oil spray applications. Reliance has had to be placed on visual observations made immediately following treatment, while the water carrier was still present on the plant surfaces. When this had evaporated it was extremely difficult to determine with any accuracy just what portions had been properly covered. Smith (1), in studying citricola scale control with oils, has attempted to eliminate the factor of coverage from his results by assuming that the presence of live scale on a definite portion of a leaf on which the remaining scale were dead indicated that coverage was not obtained on that portion; whereas the presence of live scale scattered over the leaf indicated that the treatment was defective in some other manner. The resort to such an expedient only serves to emphasize the need for a simple and rapid method of detecting the presence and location of surface oil on the host plant, and such a method is consequently presented herewith

Extensive studies of the oil depositing characteristics of petroleum insecticides have been made by various investigators in recent years. English (2) in 1930 described a method of ether extraction of the oil from discs cut from leaves. Later Dawsey & Haas (3) made refinements in this method, particularly by removing the natural oils and waxes from the extract and recovering the pure mineral oil. By this method it is possible to determine the quantity of oil deposited on the portions of the leaves that are used as samples. Although the method is limited because it is too laborious to be easily applied in the field, and because it is only applicable to determination of deposition on leaf surfaces, still Allison (4) has used it to study such factors as the influence of character and amount of spreader, type of spray application, and "heaviness" of the oil, on the amount of oil deposited.

The problem of oil disposition following application is considered to depend upon two factors: first, penetration into the plant tissue and second, evaporation from the surface film. Extensive studies of oil penetration into the plant tissues through a sectioning and staining technique have been made by Knight and his co-workers (5), who made observations on such penetration where an extremely heavy deposit of oil was made; and later by Rohrbaugh (6), who studied penetration following spray operations. The technique used is, however, highly specialized and is not applicable to an extensive study. Some such method as that of English could be used for the study of evaporation of oil from the surface film, since such a method determines all the oil present both on and within the plant tissue. If this method were supplemented by a method for determining only surface oil films, such as is presented below, complete information on oil disposition would be

obtained, since penetration could be calculated by the difference between total oil and surface oil.

DETECTION OF SURFACE OIL FILMS.—The possibility of detecting free oil on leaf surfaces by means of adherent powders such as are used in finger print detection, was conceived by Pittman & McGovern (7). They made tests, using ash leaves, with zinc stearate, diorthotolyl guanidine, formaldehyde analine, talc, face powders and aluminum powder. Of these materials talc and aluminum powder gave the best adherence on oiled surfaces, and aluminum powder was selected as preferable because of better color contrast obtained.

The authors found that aluminum powder when used on orange leaves adhered slightly to unoiled leaves. Consequently further tests were made, chiefly with colored powders and pigments such as lamp black, kelp charcoal, willow charcoal, iron oxide, zinc oxide, manganous oxide, magnesium carbonate, talc, colloidal clay, and flowers of sulfur.[2] Of these materials the sulfur was outstandingly superior to any of the others, in that it did not adhere in the least to unoiled leaf surfaces, but was extremely sensitive to minute films of oil (Plate 47A). The color contrast was such that the slightest trace of sulfur against the green leaf as a background could be easily seen

Method· Place flowers of sulfur in a can or bottle of convenient size covered with cheese cloth or fine wire screen. Sift an excess of the sulfur onto the surface to be tested, invert the surface and shake moderately. Apply a second coating of sulfur, shake off the excess, and finally blow off with the breath any remaining loosely-held sulfur.

MEASUREMENT OF SURFACE OIL FILMS.—In an attempt to devise a practical analytical method for quantitative determinations of oil films on citrus foliage a number of procedures were scouted, both by Pittman and McGovern and the authors Among the procedures tried and abandoned were the measurement of oil films imparted to water from oiled leaves, the quantitative measurement of absorbent powders, and direct weighing techniques The method finally adopted was originated by Pittman and McGovern and developed by the authors. It consists essentially in washing the leaf surfaces with an oil solvent, evaporating the solvent and weighing the residual oil. Several solvents were tried, including ethyl ether, petroleum ether, heptane, and methylene chloride. Methylene chloride[3] was selected because of its consistently

[2]It is important to use the sublimed flowers of sulfur rather than any of the ground dusting sulfurs inasmuch as the latter adhere quite tenaciously to unoiled leaf surfaces.

[3]Methylene chloride (dichloro-methane, CH_2Cl_2) is a colorless liquid: M. W. = 84.9; B. P. (°F at 1 atm.) = 105; Sp. Gr. (water = 1) = 1.35 (8).

low extraction on untreated leaves and its consistently high percentage recovery on oiled leaves. Technique using methylene chloride is given below.

Method: Wash the surfaces to be tested with a spray of methylene chloride, allowing the washings to run into a beaker. Filter the combined washings through a Munktell quantitative filter paper into a weighed evaporating dish, washing the filter thoroughly with fresh solvent. Evaporate the solvent on a water bath maintained at 45°C., dry the dish in an oven at 45°-50°C. for 2 hours, cool in a desiccator and weigh. Calculate to milligrams of oil per 100 square centimeters of surface area.

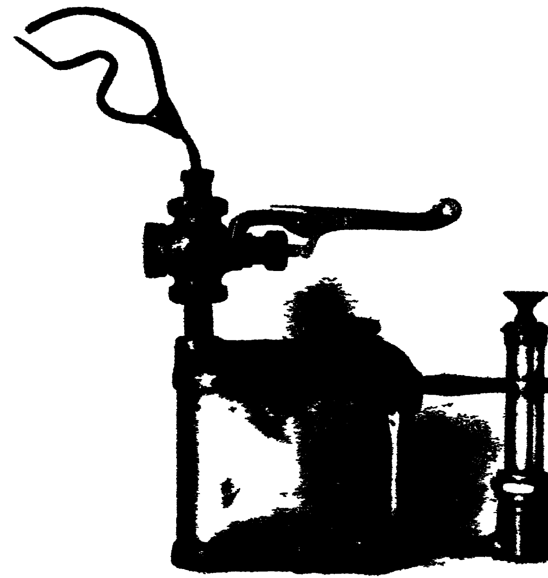
Notes on Technique: In no case should samples be washed with the solvent before they have dried from the spray treatment. Under ordinary field conditions this requires from one to two hours after spraying.

The sample taken should, for the sake of reasonable accuracy in area determinations, be not less than 10 individual leaves, and for the sake of accuracy in weighing technique, should yield not less than about 30 milligrams of oil.

The washing should be performed in such a manner as to avoid cutting into the waxy leaf covering with the solvent. For this purpose the authors used a wash bottle constructed from the body of a gasoline blow-torch (Plate 47B). The torch part was removed and a whistle valve operating by means of a lever was connected to the fluid outlet To the valve was connected a short copper tube terminating in a burner tip with small outlet hole. The fine stream of solvent issuing from the burner tip was made to impinge upon a flat plate adjusted just below it so that the stream was broken into a flat fan-shaped spray. With the spray properly adjusted, the leaf surface could be washed very quickly and thoroughly without appreciably disturbing the waxy coating.

Blank and Check Analyses: Certain blank tests were made by treating leaves and glass plate blanks simultaneously and determining oil films on both. This method was soon found to be unreliable due to rapid absorption of oil into the leaves with consequent low apparent results. For this reason the method has been checked only indirectly by determining the loss on a weighed quantity of spray oil subjected to the analytical procedure, and by determining the amount of residue obtained from untreated leaves subjected to the analyses. Blanks on oils show a loss of 3–5% with light oils, and less with heavy oils. The residue obtained on treating blank leaves has been found to vary from 0 to 0.7 milligrams per 100 square centimeters of surface area. Since these factors tend to balance out, and are within the limits of accuracy considered

A—Flowers of Sulfur used to indicate the location of free mineral oil on the surface of an orange leaf



B—Leaf Washing Device used by the authors in the determination of free surface oil

practical in this work, correction factors have not been used by the authors on results obtained by the methylene chloride method.

Determination of Surface Areas: Since the results are reported in terms of weight of oil per unit of surface, it was necessary to devise a rapid practical means of approximating the amount of surface used. Most of the work done so far has been on leaves, so fruit or wood surface has therefore been approximated merely by calculating the area of a cylinder or sphere respectively from the average of maximum and minimum circumference measurements.

A more elaborate study was made in determining an approximate formula for surface area calculations on leaves. To avoid the necessity of measuring the area of each leaf with a planimeter, an empirical equation was calculated from measurements of over 200 Valencia orange leaves. With leaves whose midrib length from tip to petiole is not less than 8 cm. or more than 12 cm. there is a definite relationship between the product of the length times the width and the actual area. When the ratio $\frac{\text{area}}{\text{length x width}}$ is plotted against the length times width product a straight line curve is formed in these limits[4], as is shown in Figure 85. With smaller leaves the ratio drops off markedly, while with larger leaves the variation is too great for the method to be reliable. In practise, average sized, normally shaped mature leaves are chosen, the length and width measured and the area calculated to the nearest square centimeter either from the graph or from Table 1.

TABLE 1. FACTORS FOR CALCULATION OF LEAF AREAS

Length x width Product in sq. cm.	Multiplied by factor to obtain area
25–33	.64
33–47	.65
47–62	.66
62–76	.67
76–90	.68

DISCUSSION.—The use of sulfur to detect oil films was thoroughly tested, both in the laboratory and in the field. Results with it were found to be entirely satisfactory within the following limits of application:

1. The sulfur dust is very sensitive, but only to free surface oil.

[4]The equation for this curve is $Y = .0007X + .622$, where $Y = \frac{\text{area}}{\text{length x width}}$ and X = length x width. The variation of individuals from this curve is noted by the standard deviation ($\delta = .005$) which is relatively small.

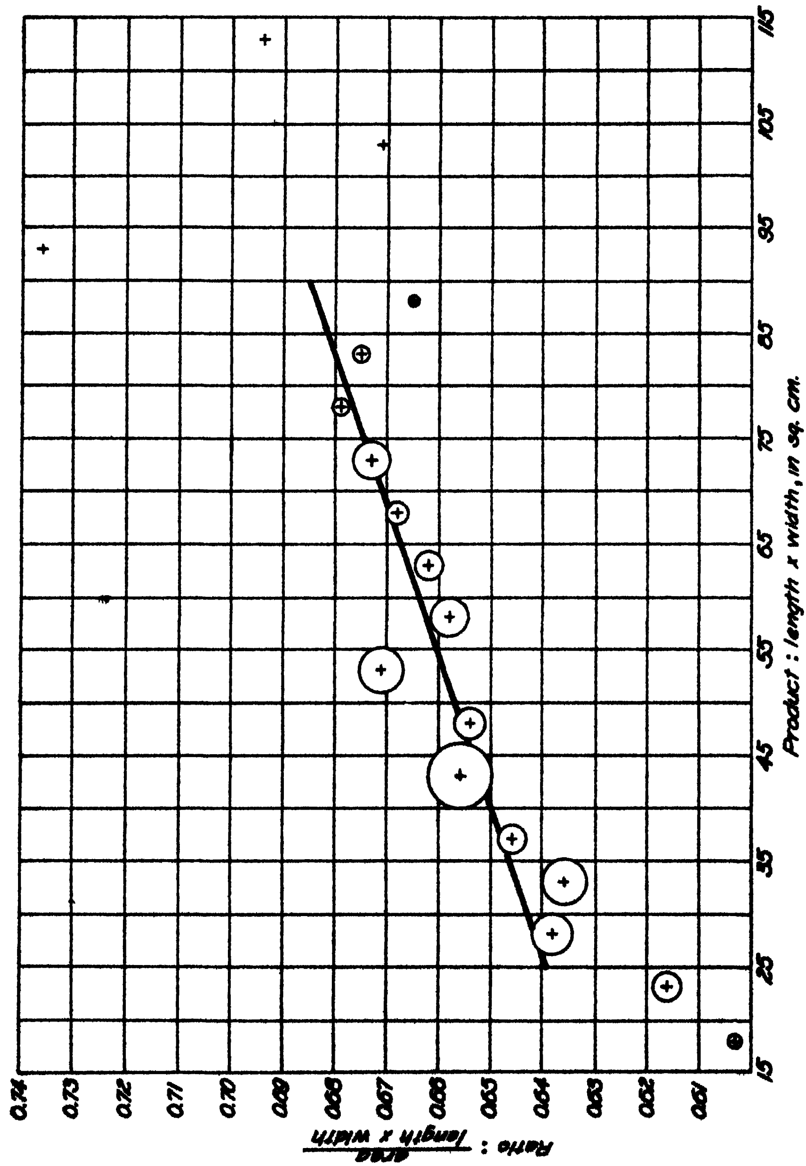


Fig. 85.—Area of valencia orange leaves based on measurements of length and width.

2. The presence of dust on leaf surfaces does not interfere with the test, although tests should not be made when foliage is wet.

3. The amount of sulfur dust retained by the leaf surfaces can be used to indicate visually differences in amounts of oil of a ratio of 1:2 or greater, provided that the lightest deposition checked does not exceed about 30 milligrams of oil per 100 square centimeters of surface.

The practical value of this method for detecting the presence of oil films on foliage depends largely on the facility with which it can be applied in the field. It can be used to check rapidly and thoroughly the effectiveness of any oil spray treatment in terms of coverage efficiency by testing samples taken from different locations in the trees treated. Dorsal and ventral leaf surfaces can be checked separately and checks can be made on twigs and fruit In this connection, it should be observed that the oil absorption rates of different parts of the tree vary greatly and consequently comparisons of deposition on different parts of the tree should be made as soon as possible after the moisture from the spray has evaporated

A laboratory test may be used to illustrate the use and limitations of the sulfur dust method A group of leaves were treated with oil simultaneously, in such a manner that the exposed surfaces of all received approximately the same amount of oil per unit area. Half the leaves exposed the dorsal surface, and half the ventral surface. A leaf from each group was tested at given intervals by the sulfur dust method. Leaves tested immediately after treatment showed about one-third less oil on the ventral than on the dorsal surface. After six hours hardly any oil remained on the ventral surface, whereas at the end of eight hours there was only a slight decrease of oil from the dorsal surface The sulfur dust showed traces of oil remaining on the dorsal surface for more than 10 days after treatment.

The methylene chloride surface washing method presented is applicable to the determination of total oil deposited by petroleum insecticides provided that the determination is made before any appreciable penetration of the oil into the plant tissues has occurred. This can be accomplished most satisfactorily by sampling the dorsal leaf surfaces as soon after application as possible. Characteristic results obtained by determining total deposition of oil in this manner are given in Table 2, where the quantity of oil deposited by different degrees of thoroughness of application of the same oil spray is shown.

This method is also admirably adapted to the determination of that portion of the original oil which remains as an effective insecticide at any given time, as it measures only the oil present on the host surface.

TABLE 2. LABORATORY TEST, CITRUS CUTTINGS, 2% LIGHT OIL EMULSION

Degree of application	Mg. Oil/100 sq. cm. dorsal leaf surface
Light	3.0
Average	6.5
Average	6.5
Average	6.5
Average	7.5
Heavy	16.5

It is a well known fact that the efficiency of oil sprays on citrus varies greatly between the different morphological parts of the tree (9). This

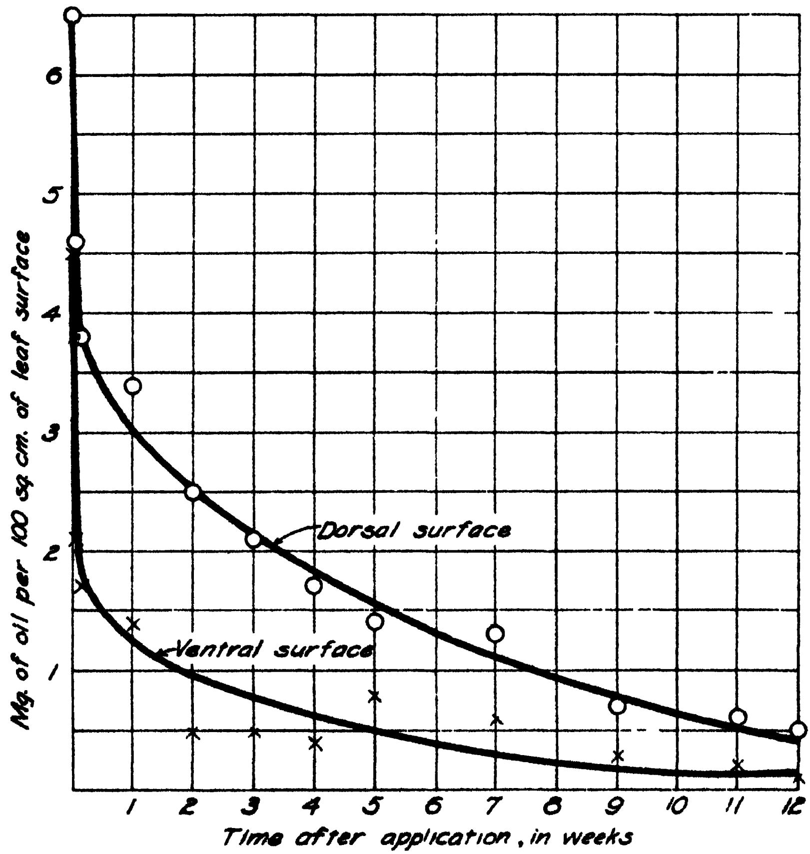


Fig. 86.—Permanence of oil film on foliage.

is due, at least partially, to the fact that oil deposition and retention are influenced by the type of surface. By means of the methylene chloride surface washing method, the amount of oil retained by any

surface at any time can be readily determined. Table 3 contains representative results on the determination of the oil present on three different surfaces of lemon trees about one hour after they were sprayed commercially with a medium oil emulsion at 2% dilution.

TABLE 3. QUANTITY OF OIL RETAINED BY DIFFERENT HOST SURFACES

Surface	Mg. oil/100 sq. cm.
Leaf (dorsal)	6.0
Leaf (ventral)	5.0
Fruit	6.5

There are numerous features related to the problem of the deposition and retention of surface oil films which are adaptable to study by means of the methylene chloride surface washing method. The results of very brief studies of two such features are presented as illustrating the scope of application of the method. The first study is on the rate of decrease of surface oil as influenced by the time interval following application. The accompanying graph (Fig. 86) shows the rate of decrease of surface oil from both dorsal and ventral leaf surfaces of lemon following a commercial oil spray treatment. The second study is on the effect of type of emulsion on oil film permanence. Table 4 shows the quantity of oil found on the dorsal leaf surfaces of citrus seedlings where three types of oil sprays were used, (a) a permanent emulsion, (b) a commercial emulsion of the "quick breaking" type, and (c) a mechanical mixture of oil and water with a small amount of spreader.

TABLE 4. OIL DEPOSITION AND RETENTION AS AFFECTED BY TYPE OF EMULSION

Type of spray	Mg. oil/100 sq. cm. 1 hour after application	Mg. oil/100 sq. cm. 2 weeks after application	Per cent loss from surface in 2 weeks
a	5.1	2.7	47
b	8.6	3.3	62
c	8.4	2.7	68

The above illustrations are only a few examples of the possible uses of the methylene chloride surface washing method. They indicate, however, that by its use much valuable information concerning petroleum insecticides can be obtained since a direct study can be made of the characteristics of the surface oil film deposited by the insecticide, and it is obvious that in studying the oil remaining on the sprayed surface, a study is being made of that portion of the oil deposited that has insecticidal value.

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Fall canker worm, *Alsophila pometaria* Harris, was extraordinarily abundant and injurious in southwestern New England and southeastern New York last spring, and naturally there has been a serious question as to whether there would be a repetition of the outbreak next year. It is well known that extreme abundance of various insects is normally followed by a great reduction due to natural causes, and in the case of the apple tent caterpillar it is undoubtedly true that parasites and possibly predators are important elements in bringing about this natural control. The factors producing the well known fluctuations in the abundance of the fall canker worm are not so well known. The insects are already issuing at the time of writing, mid-November, and as yet it is early to forecast probabilities as to the abundance of the canker worms next spring. There certainly will be some, and judging from earlier experience with this insect it is quite probable that they will be relatively more abundant in areas where they were not extremely numerous last spring, and that in the more densely infested sections of last spring there is a possibility of some and perhaps a material reduction in the numbers of these pests. There is an excellent opportunity to obtain data upon the situation, and it is hoped that entomologists and other observers in the areas which suffered severely last year will make note of conditions the coming spring and advise as to the outcome.

E. P. FELT

STUDY OF AUXILIARY GASES FOR INCREASING THE TOXICITY OF HYDROCYANIC GAS[1]

Part I. Studies with Ladybird Beetles as Indices of Toxicity[2]

By F. S. PRATT, A. P. SWAIN and D. N. ELDRED, *the Pacific R & H Chemical Corporation, El Monte, California*

ABSTRACT

In the studies reported here, almost 200 chemicals covering a wide range of organic and inorganic compounds were used in qualitative and toxicity tests for the purpose of determining their action on ladybird beetles in conjunction with HCN. It was found that several were toxic in themselves, but few approached HCN in degree of toxicity. Some were very irritating to the insects, and some were stupefying. In general it was found that those compounds whose vapors were effective in increasing the toxicity of HCN were either predominantly toxic, or moderately toxic and irritating. The majority of compounds having value fell in the latter class. Certain of the gases which stupefied the insects actually decreased the toxic action of HCN. The vast bulk of the compounds had apparently no effect, neither increasing nor decreasing the toxicity of HCN.

Fumigation of citrus trees with hydrocyanic acid for the control of scale insects has been practised for almost half a century in California. Until comparatively recently most species of scale infesting citrus have been readily controlled by fumigation and at present this method plays an exceedingly important part in the field of citrus pest control However, in certain restricted areas in Southern California, there have developed scale that are able to withstand concentrations of HCN which in turn cause injury to the host plants. In other words, certain species of these scale have either built up a tolerance to HCN through successive generations or developed new strains of such a hardy character that normal dosages of HCN are not effective.

Since this is a condition that must be met, it appears that a possible method of so doing consists in increasing the toxicity of HCN to the insects. One means of accomplishing this would be the addition to HCN of some auxiliary gas which would improve the control of scale, either by its own toxic action or by its increasing the toxicity of HCN[3].

[1]Contribution from the Laboratories of the Pacific R. & H. Chemical Corporation.

[2]This is a report of the preliminary studies made using ladybird beetles as indices of toxicity. Later papers will report studies with various of the scale insects infesting citrus orchards in Southern California.

[3]The idea that formaldehyde, which seems to be irritating to some insects, might irritate or stimulate scale and thereby render it more susceptible to HCN was advanced by Neuls (1). He performed some tests using HCN plus formaldehyde, and other tests with HCN alone, using ladybird beetles as the index of toxicity. These experiments seemed to indicate that 0.15% formaldehyde in the atmosphere increased the killing efficiency of HCN concentrations varying from 0.05% to 0.25%, both gases reported as per cent by weight in air.

From the beginning of the study undertaken to search out auxiliary gases which would add to the toxic effect of HCN, those engaged in the work herein reported held the viewpoint that the auxiliary gas might be irritant, toxic or non-toxic, but that any effect such as irritating, stimulating or stupefying might add to the toxicity of HCN.

In order to investigate as thoroughly and completely as possible the whole field of chemical substances the following basis of selection was used:

(1) Chemical structure: representatives of classes of inorganic and organic substances.

(2) Chemical characteristics: boiling point not too high; vaporization feasible, not decomposed; preferably not chemically reactive with HCN.

(3) Chemical warfare data on toxic and irritating gases.

(4) Cost: giving preference to substances which could be produced at a cost feasible for this use.

It is to be understood that substances to qualify as fumigants must be in the form of a gas or vapor. Liquids of boiling points much higher than atmospheric temperature were vaporized by a suitable heating coil, and these substances then existed as vapors carried in the air.

When any substance or compound was found to have some value, other compounds of related chemical structure were tested.

TABLE 1. COMPOUNDS TESTED FOR TOXICITY TO INSECTS

Alone or in Combination with HCN

Acetates	9	Iodides	1
Acids (organic)	5	Inorganic compounds	24
Alcohols	12		
Aldehydes	14	Ketones	7
Benzene derivatives	12	Nitrates	2
Bromides	9	Nitriles	2
Butyrates	1	Nitrites	3
		Nitro compounds	5
Chlorides	21	Nitrogen compounds	2
Chlorhydrins	3		
Cyanogen compounds	8	Oils	6
Esters	5	Phenols	7
Ethers	7	Propionates	1
		Sulphur compounds	7
Formates	3		
		Miscellaneous compounds	5
Hydrins	1		
Hydrocarbons	8	Total	190

The ultimate aim of this study was improvement in the control of scale insects infesting citrus and the value of any auxiliary fumigant could be given finally only in terms of toxicity to these scale. However,

for preliminary studies, it was believed that through the use of active insects valid indications could be obtained with greater ease and more rapidity than through the use of scale insects. The responses of the latter to stimuli are difficult to observe, several days following treatment are required for the determination of toxicity and wide variations in natural mortality occur. Previous studies (2, 3) had indicated that certain adult ladybird beetles were satisfactory in as much as their reactions were marked, mortality could be determined within 24 hours, abundant supplies were readily available and the toxicity of HCN to the beetles was approximately the same as to adult red scale.

In the first series of experiments three species of ladybird beetles and one of granary weevils were used. Cryptolaemus beetles (*Cryptolaemus montrouzieri* Muls.) were obtained from a local insectary, the convergent ladybird beetle (*Hippodamia convergens* Guerin) and its variety *H. ambigua* LeConte from hibernating colonies in the nearby mountains and the granary weevil (*Sitophilus granarius* (Linn.)) from an infested flour mill. Preliminary toxicity tests (Table 2) showed that the granary weevil was unaffected by the lower concentrations of HCN toxic to ladybird beetles and that results with Cryptolaemus were more variable than with the convergent ladybird beetle. Consequently results reported in this paper have been limited to those obtained with the ladybird beetle, *H. convergens* Guerin.

TABLE 2. PRELIMINARY TOXICITY TESTS

Toxicity of HCN alone to four insects
Per cent kill of insects

		Ladybird beetles			
Per cent HCN	Exposure in minutes	*Hippodamia convergens*	*Hippodamia ambigua*	*Cryptolaemus montrouzieri*	*Sitophilus granarius*
0.2	10	85	70	15	0
	20	95	95	95	0
	30	100	100	100	0
1.0	30				20
2.0	30				30
3.0	30				90
4.0	30				100

QUALITATIVE STUDY OF GASES.—In order to observe the effects on insects of a large number of gases, under fairly uniform conditions, and in a reasonably short period of time, a qualitative method was devised. This was intended to be preliminary or scouting in nature, and served to indicate which compounds might deserve more thorough investigation.

Method: The method used in making uniform qualitative tests was to place several insects in a glass cell and circulate air carrying a known

concentration of the gas through the cell. The desired concentration of the gas was established in a large glass bottle by an appropriate measurement, vaporizing a measured quantity of liquid when that was the form received. The atmosphere in the bottle was circulated from the bottle through the observation cell and returned to the bottle by means of a mercury pump (Plate 48).

The concentration of gas in air to be used was decided upon as 0.20% by weight. There were good reasons for selecting this amount: (a) HCN was the standard of comparison, and 0.20% HCN by weight in air had been found to give a 100% kill of beetles with a minimum exposure from 20 to 30 minutes; (b) this concentration and exposure, when converted to commercial operating conditions, probably represents the maximum amount which could be used on the basis of such considerations as cost and human tolerance. Formaldehyde, for example, was found to be intolerable to workmen when introduced under tents at 0.05% or stronger.

A constant concentration of the test gas in air was used throughout these qualitative tests, rather than the typical decreasing concentration found in tree fumigation, because this served the purpose of providing comparable results with the most simple equipment.

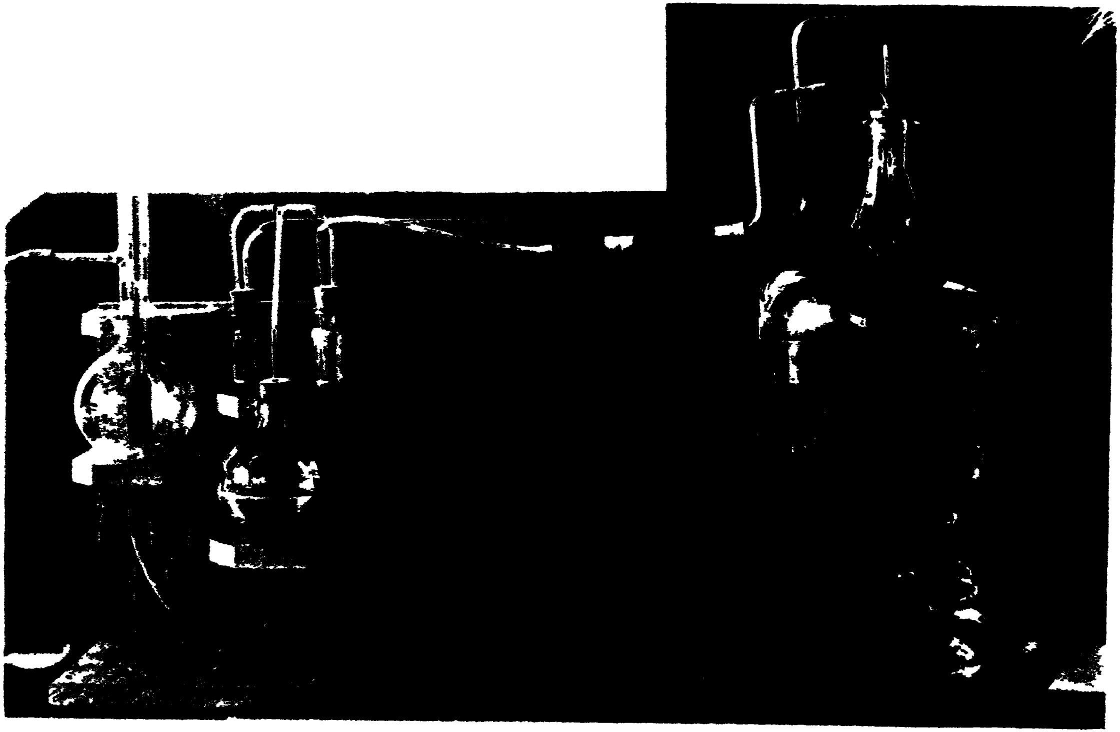
The insects were observed for a period of exposure of 30 minutes and their visible reactions during this time recorded. At the end of the 30 minutes exposure the beetles were collected in a small cotton sack and set aside in fresh air for 24 hours, at which time they were examined to determine whether dead or alive; if not active they were placed on a watch glass over a hot plate and gradually warmed, after which, if still inactive, they were recorded as dead.

In order to standardize the record of effects noted, the following terms were used, referring to beetles:

(1) Very active; flapping wings, crawling.
(2) Active: Crawling.
(3) Inactive: Not crawling, but able to move.
(4) Stupefied: Slight movement, such as lifting legs occasionally.
(5) Dormant: No movement.
(6) Dead.

The following table (Table 3) is an example of the type of study made and the method used in recording the observations.

Classifications of Gases by Effects. Judging by the predominating reactions resulting from 30 minutes exposure to 0.2% by weight in air of each gas, the more significant results were as follows:



Apparatus for Qualitative Study of Gases for Observing Visible Effects on Insects. Large glass bottle acts as gas chamber and mercury pump serves to circulate gas through observation cell and returns to bottle

1. Strongly toxic (100% kill in 30 minutes): hydrocyanic acid, cyanogen chloride, hydrogen chloride, thionyl chloride, camphor.

TABLE 3. QUALITATIVE OBSERVATIONS: EFFECTS OF GASES ON BEETLES AND WEEVILS

SALICYL ALDEHYDE, 0.2% in air. Room temp.: 24°C.
Exposure: 30 minutes Rel. hum.: 52%

Time of observation	*H. convergens*	*H. ambigua*	*C. montrouzieri*	*S. granarius*
1 minute	active (irritated)	active (irritated)	active (irritated)	active
3 minutes	very active	very active	very active	active (irritated)
5 minutes	" "	" "	" "	"
10 minutes	stupified	active	3 dormant, 2 stupified	"
20 minutes	stupefied	stupefied	stupefied	inactive
30 minutes	stupefied	stupefied	3 dormant, 2 stupefied	"
24 hrs. later	all dead	all dead	2 dead	all alive

CARBON DIOXIDE, 100% atmosphere. Room temp.: 26°C.
Exposure: 30 minutes Rel. hum.: 46%

Time of observation	*H. convergens*	*H. ambigua*	*C. montrouzieri*	*S. granarius*
1 minute	stupefied	stupefied	stupefied	stupefied
3 minutes	dormant	dormant	dormant	dormant
5 minutes	"	"	"	"
10 minutes	"	"	"	"
20 minutes	"	"	"	"
30 minutes	"	"	"	"
24 hrs. later	all alive	all alive	all alive	all alive

Note: *H. convergens* and *H. ambigua* will survive an exposure of *4 hours* to 100% CO_2 atmosphere

HYDROGEN, 100% atmosphere. Room temp.: 23°C.
Exposure: 30 minutes Rel. hum.: 66%

Time of observation	*H. convergens*	*H. ambigua*	*C. montrouzieri*	*S. granarius*
1 minute.	stupefied	stupefied	stupefied	stupefied
3 minutes	dormant	dormant	dormant	dormant
5 minutes	"	"	"	"
10 minutes	stupefied	stupefied	"	"
20 minutes	"	"	"	"
30 minutes. . .	"	"	"	"
24 hrs. later	all alive	all alive	3 dead	all alive

NITROGEN, 100% atmosphere. Room temp.: 23°C.
Exposure: 30 minutes Rel. hum.: 68%

Time of observation	*H. convergens*	*H. ambigua*	*C. montrouzieri*	*S. granarius*
1 minute	stupefied	stupefied	stupefied	stupefied
3 minutes	dormant	dormant	dormant	dormant
5 minutes	"	"	"	"
10 minutes	"	"	"	"
20 minutes	"	"	"	"
30 minutes	"	"	"	"
24 hrs. later	all alive	2 dead	all dead	all alive

2. Toxic and irritating (partial kill in 30 minutes): salicyl aldehyde, benzaldehyde, allyl iso-thiocyanate, chloropicrin, benzyl bromide, brom benzyl cyanide, thiophenol, cyanogen, phosgene, allyl bromide, acetophenone, creosote, ethylene-chlorohydrin, (hydrogen 100%), pyrethrum powder.

3. Non-toxic and Irritating: benzyl chloride, xylyl bromide, acetic acid, eucalyptus oil, carbon tetrachloride, pyridine, bromine, nicotine.

4. Stupefying: carbon dioxide, carbon monoxide, hydrogen sulphide, hydrogen iodide, phosphine, arsine, ethyl alcohol, n-propyl alcohol, iso-propyl alcohol, amyl alcohol, n-butyl alcohol, trichlor ethylene, nitrobenzene, benzene, monochlor benzene, furfuraldehyde.

5. No effect (or slight effect): 67 or more compounds tested.

TOXICITY STUDIES OF GASES WITH HCN.—On the basis of the observations made in these tests as to the visible reactions of the beetles to the various gases, toxicity studies of selected gases in conjunction with HCN were carried on. Results were based on replicated tests with comparatively large numbers of beetles in terms of per cent kill, the object being to shorten the time to kill 100% through the use of an auxiliary gas with HCN, as compared to the time required to obtain 100% kill with HCN alone.

Technique of Toxicity Studies. Supplies of *H. convergens* Guerin were collected periodically from colonies in the nearby mountains and were kept in a mixture of leaves and earth in an ice box As required, beetles were removed from the supply, warmed in an electric oven at 40°C. until active (usually 5 minutes was sufficient), after which 20 were placed in a small cheesecloth bag for use

In a gas-tight chamber (usually a 46 liter glass bottle) a concentration of the auxiliary gas at 0 1% in air by weight was obtained. Into this 6 bags of beetles were introduced and after 10 minutes exposure, sufficient HCN was added to make a concentration of 0.2% HCN in air by weight. Five minutes later one bag of beetles was removed, and at the end of each 5 minute period thereafter another bag was taken out. These were placed in suitable storage until the next day when mortality counts were made Any beetles that did not show signs of life on examination were warmed for a few minutes in a watch glass over a heater and if this did not cause them to show life, they were considered as dead. One check test with HCN at 0.2% concentration was made each day, while at least 5 separate tests on two days were made with each auxiliary gas.

Basis of Classifying Results. In order to judge results toxicity curves were drawn up for HCN alone and in combination with other gases. In these the percent kill was plotted over the time of exposure at 5 minute intervals. A large series of tests with HCN alone were made, using concentrations of 0.1, 0.2, 0.3, and 0.4% in air by weight. In figure 87A are shown the toxicity curves obtained.

In the cases of the auxiliary gases with HCN the toxicity curves of the combination was plotted together with that of HCN alone at 0.2% in air

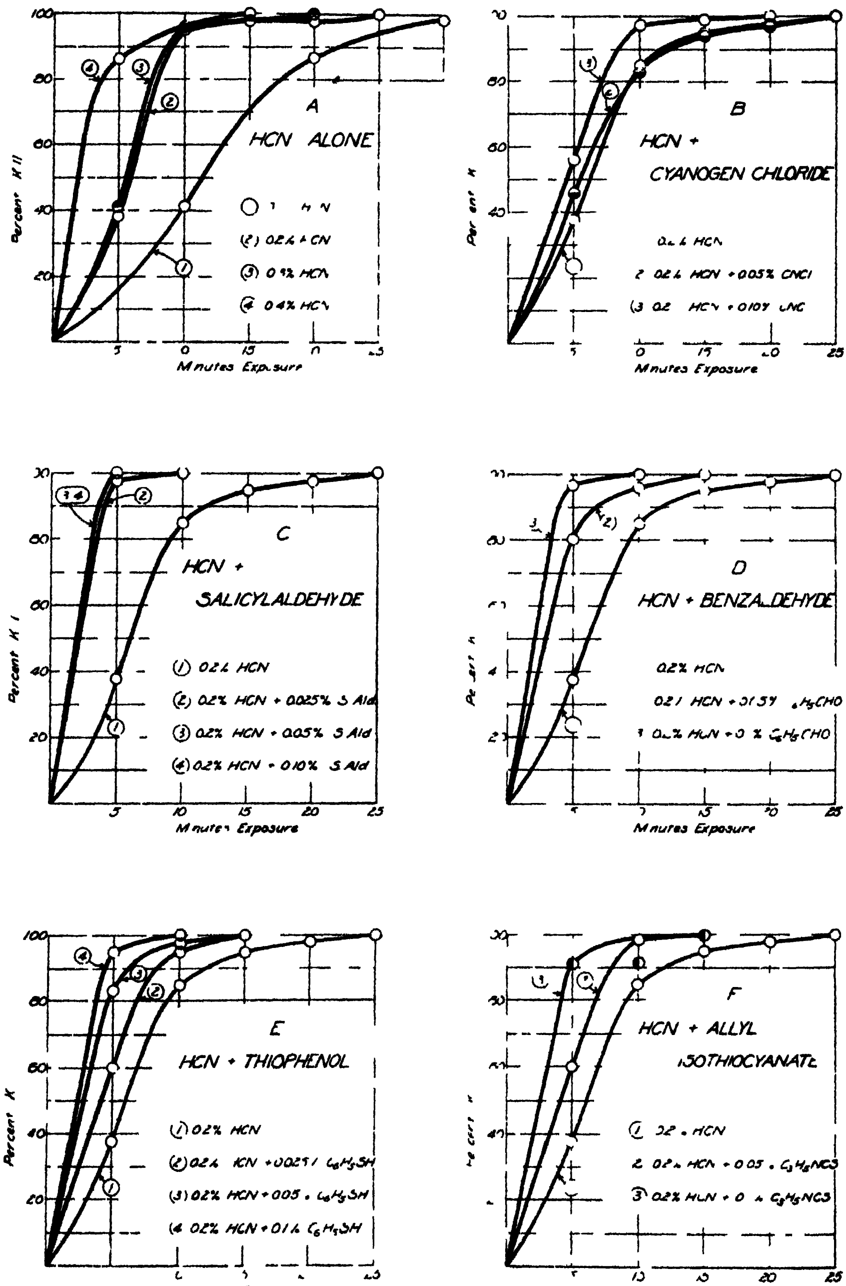


FIG. 87.—Toxicity Curves—Auxiliary Gases with HCN

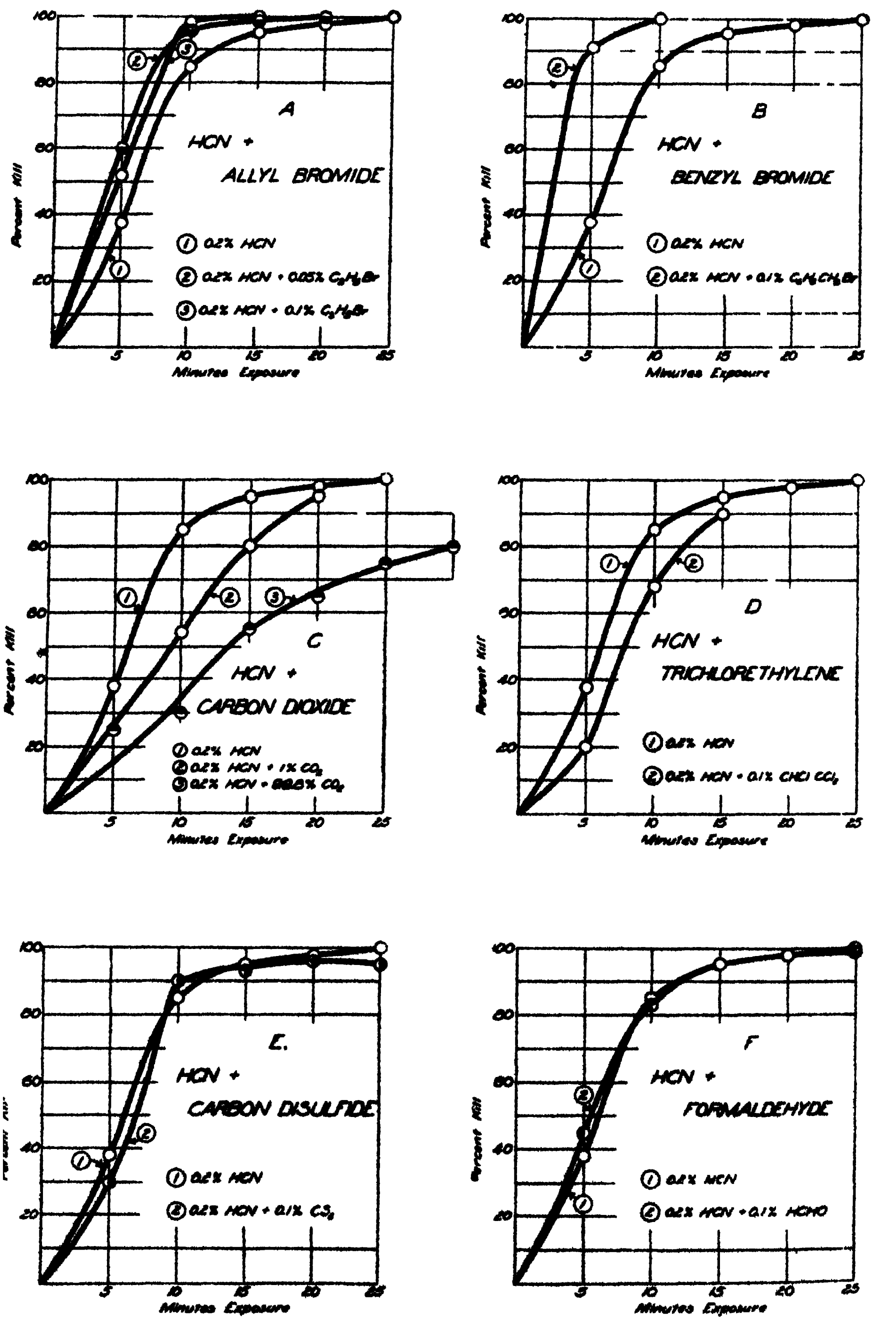


FIG. 88.—Toxicity Curves—Auxiliary Gases with HCN.

by weight so that comparisons were readily made. Unless there was a marked straightening of the curve, showing a reasonably wide divergence from the HCN curve, results were considered as negative. When results showed that 0.1% in air of the auxiliary gas in conjunction with HCN was of value in shortening the time to kill, further experiments were performed using lower concentrations of the auxiliary gas, first 0.05% and later 0.025%. Such tests served a double purpose; first, to indicate the lowest limits of effectiveness of the auxiliary gas and second, to verify the previous results.

Effective Auxiliary Gases. Of the 33 compounds which were found to be definitely effective by shortening the required exposure time for HCN to 15 minutes or less, the seven best are as follows, in their order of excellence:

salicyl aldehyde
benzaldehyde
ethyl thiocyanate
allyl iso-thiocyanate
thiophenol
benzyl bromide
perchlor methyl mercaptan

The balance of the compounds showing value are grouped as follows:

Acetates: beta brom ethyl -, amyl -.
Acids, organic: acetic -, pyrogallic -.
Alcohols: methyl -.
Aldehydes: croton -, butyric -, isovaleric -.
Benzene derivatives: benzyl chloride, benzoyl chloride.
Bromides: xylyl -.
Chlorides: (benzyl -, benzoyl -) acetylene tetra -, propylene -.
Chlorohydrin: epichlorhydrin.
Cyanogen: methyl thiocyanate.
Ether: beta naphthyl ethyl -.
Ketone: acetophenone.
Nitrile: phenylacetonitrile
Nitrogen compound: pyridine.
Nitro: chlorpicrin, nitrobenzene
Sulphur compounds: thiophosgene, methyl sulphate.
Miscellaneous: camphor, pyrethrum powder.

Discussion.—The most effective gases in increasing the toxicity are found to come under the classes referred to under Qualitative Tests as (1) strongly toxic and (2) toxic and irritating, while the half dozen most effective come under the second classification. As an example of the strongly toxic group, cyanogen chloride at 0.10% concentration shortened the time to kill slightly but at 0.05% was of no value (Fig. 87b). In fact this particular compound does not appear under the first thirty-three most effective. Certain of the compounds used in the qualitative tests, such as hydrogen chloride and phosgene were not used in the

toxicity tests for various reasons, as for example extreme toxicity to humans.

Of the seven most effective gases, all used in qualitative tests were markedly irritating to beetles and partially toxic. Of these salicyl aldehyde ranks first, with benzaldehyde a close second. Concerning the question of the comparative toxicity of a given group of compounds of similar structure, this work tends to show that the toxicity increases with the increase in boiling point. Formaldehyde with a boiling point of —21°C. was relatively ineffectual (Fig. 88f), benzaldehyde with a boiling point of 180°C. was the second best (Fig. 87d), and salicyl aldehyde, (Fig. 87c) with a boiling point of 196°C. was outstandingly the best.

With salicyl aldehyde as an example of this second group, it was found that a concentration of 0.10% with HCN shortened the time to obtain a 100% kill to 5 minutes, as did a concentration of 0.05% (Fig. 87c). This was the shortest exposure time on which observations were made. Even at 0.025% concentration 100% kill was obtained in 10 minutes. This was the most outstanding auxiliary gas found, although benzaldehyde was a close second, 100% kill being obtained in 15 minutes at 0 05% concentration with HCN and in 10 minutes at 0.10% (Fig. 87d). Toxicity curves for two other of the more effective gases in this group are shown, Figure 87e showing the effect of thiophenol in shortening the time to obtain a 100% kill to 20 minutes when used at a concentration of 0.05% and to 10 minutes at 0.10%. In Figure 87f toxicity curves for allyl isothiocyanate are shown, where a 100% kill is obtained in 15 minutes at a concentration of 0.01%, and in 10 minutes at 0.05%.

In the third group (non-toxic and irritating) there are some of the more effective auxiliary gases, such as benzyl chloride (Fig. 88a) and xylyl bromide (Fig. 88b) both of which shortened the time to kill 100% considerably when used at 0.10% concentration with HCN.

In the fourth group (stupefying) are some compounds that produced very interesting results. In Fig. 88d is shown the effect on the toxicity curve of adding 0.10% concentration of trichlorethylene to HCN. The combination actually produced poorer results than did HCN alone. A more striking case of this is shown with carbon dioxide (Fig. 88c) where 1% and 10% concentrations were added to HCN. This is of particular interest as it has been suggested by Hazelhoff (4) that CO_2 should accelerate the penetration of HCN into the tracheal system of insects and thereby increase its toxic action. Later Cotton and Young (5) showed that CO_2 did actually increase the toxicity of certain fumigants to the flour beetles. However in the case of the ladybird beetles it was found that the opposite result was obtained, namely that the use of CO_2

actually decreased the toxicity of HCN. These results were, by the way, the first indication of the possibility of there being such a phenomenon as was later described as "Protective Stupefaction" (6, 7).

Two examples from the last group (no effect) will suffice to show the trend of results. Carbon bisulfide (Fig. 88e) and formaldehyde (Fig. 88f) had no effect on the time to kill 100% when used at 0.10% concentration in conjunction with HCN. This might be expected for at even twice this concentration they showed no visible effects on the beetles.

These studies with ladybird beetles provided ample basis for the belief that auxiliary gases could be used to advantage with HCN to provide a distinct additional toxicity. This was, of course, particularly true of salicyl aldehyde, and the additional evidence that both humans and plants seemed quite tolerant to the aldehyde indicated great value for this compound or one of like characteristics. If, or when, these results could be duplicated with scale insects as indices of toxicity, fumigation with hydrocyanic acid would be greatly improved.

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LABORATORY EXPERIMENTS WITH VARIOUS FUMIGANTS AGAINST THE WIREWORM *LIMONIUS (PHELETES) CALIFORNICUS* MANN[1]

By Russell S. Lehman, *Assistant Entomologist, Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology*[2]

ABSTRACT

Thirteen fumigants were tested on the wireworm *Limonius (Pheletes) californicus* Mann., and their median lethal concentrations in air determined under controlled conditions and compared with that of carbon disulfide. The time of exposure to the fumigant was 5 hours in all tests, the concentration being the variable factor Some wireworms that appeared to be dead 15 days after exposure to carbon disulfide recovered and were able to walk one month after the exposure. The fumigants used ranged from 0.56 to 192.9 times as toxic as carbon disulfide, allyl isothiocyanate being the most toxic.

In order to broaden the program of control work against wireworms in the Pacific Northwest, it was considered desirable to investigate a number of fumigants not heretofore used against these larvae to see if any of them were effective. Since carbon disulfide has been used successfully against wireworms and other insects, it was decided to use this fumigant as a basis for comparison. Laboratory experiments were undertaken first in order to eliminate the less effective fumigants without laborious field work.

In the early work with insect fumigants, most of the investigators, as Moore (3) and Tattersfield and Roberts (8), determined the concentrations necessary to kill 100 per cent of the insects in a fixed period of time; others, as Strand (6), determined the time required to kill 100 per cent at a fixed concentration.

Trevan (9) showed the error introduced when the 100 percent mortality point is taken as a basis for comparison and the desirability of using the 50 per cent mortality point. Strand (7) has very ably reviewed and discussed the 50 per cent point, and the writer (2) has previously used the 50 per cent mortality point as a basis for a comparison of fumigants and found it quite satisfactory.

Tattersfield and Roberts (8), in experiments with various organic compounds against wireworms (*Agriotes*), found, as did the writer, allyl isothiocyanate to be the most toxic compound tested. They listed

[1]Order Coleoptera, family Elateridae.

[2]All the experimental work for this investigation was conducted at the laboratory of the U. S. Bureau of Entomology, located at Walla Walla, Wash., M. C. Lane, in charge.

Constant Temperature and Humidity [illegible] against [illegible]

allyl isothiocyanate and chloropicrin as being of high toxicity, pyridine of moderate toxicity, and carbon disulfide of low toxicity.

Moore (3), in experiments with 28 benzene derivatives against house flies, found them all to be more toxic than carbon disulfide.

Strand (6), in comparing chloropicrin with carbon disulfide, found that 1 pound of chloropicrin effected a 100 per cent kill of *Tribolium confusum* at 25°C (77°F.), in 2 hours and 15 minutes and that when 2 pounds was used the same kill was obtained in 50 minutes. With 15 pounds of carbon disulfide 1 hour and 1½ hours were required to obtain 100 per cent mortality.

Toxicologists will certainly agree that in comparing fumigants only one factor should be varied. A majority are, no doubt, in favor of keeping the temperature and the humidity constant. Whether the time or the concentration is varied does not appear to the writer to make much difference in the accuracy of the results Richardson and Haas (4) concluded that the relative toxicity of pyridine and nicotine was approximately the same at all the time-concentration levels tested. In most cases, however, keeping the time constant and varying the concentration would seem to be the most convenient procedure and should give the same results If a saturated atmosphere of the fumigant is necessary, as used by the writer in 1930 (2), then the time must be varied to get the desired mortality. If one wishes to compare the work of others, an identical method of procedure would be necessary Strand (7) measured the toxicity of insect fumigants using a constant exposure period of 5 hours and varying the concentration of the fumigant, and the writer has adopted this method Most of the fumigants used were among those found by Roark and Cotton (5) to be 100 per cent effective against the rice weevil (*Sitophilus oryzae* L.).

MATERIALS AND APPARATUS.—The fumigants tested are listed in Tables 1 and 2. All the compounds were of the highest purity obtainable, and, with the exception of allyl isothiocyanate which was labeled "practical," were of high purity. It was necessary to dissolve several of the fumigants in water or alcohol in order that all the dosages could be measured.

The wireworms (*Limonius* (*Pheletes*) *californicus*) were obtained the preceding spring and summer by baiting with ground wheat.

The experiments were conducted in accurately calibrated 6-liter Erlenmeyer flasks, inside each of which was suspended a 40-mesh copper-wire basket 1 by 1¾ by 4 inches so that it was about 3 or 4 inches from the bottom of the flask. (Plate 49).

These flasks, containing the insects and fumigants, were kept in a

constant temperature and humidity chamber (Fig 89) similar to those described by Brindley and Richardson (1), equipped with the usual thermoregulator, mercury relay, and electric fan The light globes,

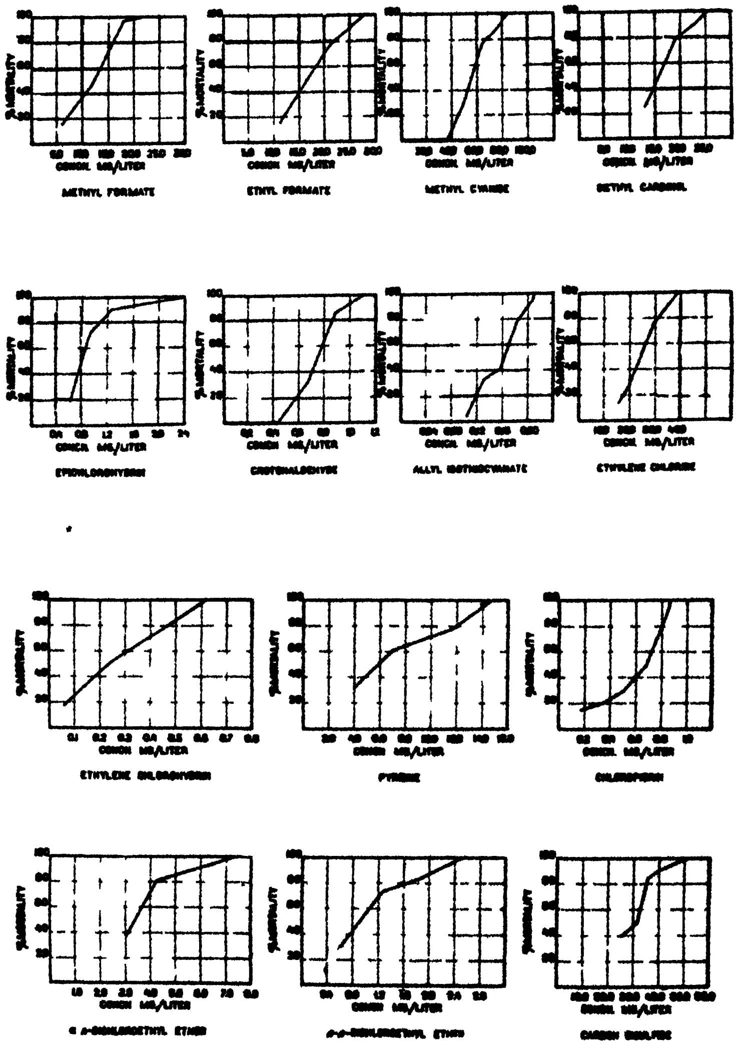


Fig 89 — Concentration mortality curves for various fumigants used against wireworms (*Limonius (Pheletes) californicus*)

which were used as a source of heat, and the inside of the chamber were painted black, and a black cloth was hung over the glass of the door These precautions were taken so that the wireworms, which are soil-

inhabiting insects, would receive as little light as possible. The chamber was maintained at a temperature of 25° ± 0.1° C., (77° ± 0.18° F.) and at 80 per cent relative humidity.

The lower concentrations of fumigants were measured in a pipette[8] graduated to 0.00033 cc. and the higher concentrations in a pipette graduated to 0.01 cc. The range of concentrations required the use of only one of the pipettes for each fumigant.

PROCEDURE.—Upon removal from the baits the wireworms were kept in outside soil cages until the first of October, when they were placed in containers without food at a temperature of 10° C. (50° F.). The experiments were conducted from October 27, 1932, to March 10, 1933. One week before the wireworms were to be employed in the experiments they were given whole wheat for food and maintained at a temperature of 20° C. (68° F.). After exposure to the fumigants they were returned to the containers with whole wheat for food. As it was important that all the wireworms should be of about the same size and weight, they were weighed several times during the experiments.

In order to condition the air in them, the flasks were placed in the constant temperature and humidity chamber 18 hours before the experiment was begun.

Twenty-five wireworms (100 in case of tests with carbon disulfide and chloropicrin) were put in each basket, the desired concentration of the liquid fumigant was pipetted into the flask, and the basket was suspended within the flask. A loosely fitting rubber stopper was lowered, inverted, into the mouth of the flask to the calibrated mark and the flask sealed with paraffin. Six flasks were placed in the constant temperature and humidity chamber at a time; one of the flasks, containing no fumigant but otherwise treated in the same way, was used as a control.

A uniform exposure period of 5 hours was allowed in all the experiments. At the end of this time the wireworms were removed from the flasks and examined. At this first examination the wireworms were observed for signs of movement but were not touched. Subsequent examinations were made 1, 3, 7, 10, 15, 30, 45, and 60 days after exposure. At each examination after the first the inactive and apparently dead wireworms were prodded with a forceps. A wireworm was considered active if it was able to walk on a flat surface, inactive if able to move but unable to walk, and dead if it did not move when prodded with the forceps. No wireworm was discarded until it had decomposed.

[8]This pipette was furnished by Dr. F. L. Campbell, U. S. Bureau of Entomology, Takoma Park, Md.

The percentage of wireworms killed by the fumigant was then calculated according to the formula previously used by the writer (2), $\frac{x-y}{x} \times 100$ = per cent killed, where x = percentage living among the controls and y = percentage living among those exposed to a fumigant. The examination made 10 days after exposure was used for determining the percentages except in the tests with carbon disulfide and chloropicrin, in which the 15 and 30 day examinations, respectively, were taken.

It was, of course, necessary to conduct a number of preliminary experiments to determine the concentrations of fumigants necessary to obtain mortalities between 0 and 100 per cent.

RESULTS.—The results obtained with the different fumigants in various concentrations are summarized in Table 1 and shown graphically in Fig. 89. The median lethal concentration, or 50 per cent mortality point, for each fumigant has been calculated from the data given in Table 1 and is shown in comparison with the median lethal concentration of carbon disulfide in Table 2.

DISCUSSION.—Until recently most entomologists working with insecticides have failed to state definitely how long after treatment their observations were made, and what was their criterion of death. Biologists have been more exact than entomologists in this regard. When an investigator does not state the time of observation, in this regard. it is assumed to be immediately after exposure. In tests of fumigants a serious error results if observations are not continued for at least several days, or until one can be certain that no further recovery will result.

The writer has selected 10 days after exposure as the time at which a comparison of the fumigants could best be made, as the subsequent examinations showed that, with the exceptions of carbon disulfide and chloropicrin, there was no further recovery after this time. With carbon disulfide, however, observations made 15 days after exposure were considered more accurate, and with chloropicrin it required one month before definite conclusions could be drawn. Actually, however, there was little difference between the percentages dead on these examinations and on the 10-day examination.

The question arises as to whether a control is necessary. Some investigators think not, especially if the natural mortality is slight. Where there is a possibility of a high natural mortality, however, a control is absolutely essential. In the case of wireworms there is that possibility, and 10 days after exposure there may be a range in natural mortality of 0 to 50 per cent among wireworms in different flasks from the same lot obtained from the same field at the same time and kept

under identical conditions. The question also arises, When is a control properly interpreted? If two sets of wireworms are taken, one to serve as a control and the other treated with a fumigant which kills or anesthetizes them, and at the end of 10 days 50 per cent of the treated lot have recovered while in the control 25 per cent have died naturally, is it correct to say that only 75 per cent were treated by the fumigant and that the fumigant killed only 33 per cent? May it not be true that, owing to the effect of the fumigant, there was not the same natural death in the fumigated lot? The wireworms in the fumigated lot did not have normal activity, and therefore natural life for some may have been prolonged. In other words, the fumigant may actually have killed the 50 per cent. This question of how best to use the control in calculating the mortality has perplexed the writer for some time, but for the present the use of the formula indicated appears to be the only logical method to follow.

It was found, as shown by the data in Table 3, that the same concentration of ethylene chlorohydrin in alcoholic solutions of different percentages resulted in a variation in toxicity to the wireworms. In other words, when solutions consisting of various proportions of ethylene chlorohydrin and ethyl alcohol were added to the flasks in such volumes that the quantity of ethylene chlorohydrin per unit volume was the same in each flask, it was found that as the proportion of ethylene chlorohydrin increased in the solution the mortality of the wireworms increased. When distilled water was used to obtain various dilutions of the ethylene chlorohydrin, however, the mortality was practically the same as one would expect with the same concentration.

An adequate explanation of this phenomenon is lacking. There should be no chemical reaction between the two compounds. It was thought at first that the ethyl alcohol might have had an anesthetic effect upon the larvae, reducing the rate of respiration and thus causing less of the ethylene chlorohydrin to enter the body But since the ethyl alcohol appeared to have little effect upon the larvae in the control, which contained the maximum quantity of ethyl alcohol used in the experiment, it is not likely that an anesthetic effect was produced. The fact that ethyl alcohol was used as a solvent for several other compounds in these experiments without this result also gives discredit to this explanation. The results obtained with ethylene chlorohydrin when not in solution compared favorably with the effect produced when the ethylene chlorohydrin was dissolved in water.

The reaction of the wireworms to chloropicrin was interesting The gas seemed to affect their nervous systems, since they were able to twist and roll but were unable to walk. Their legs did not appear to be

paralyzed, but they had no control over them. Two months after exposure to chloropicrin the wireworms were still alive but not normal. They did not feed, and they were unable to walk. They never recovered.

The results with carbon disulfide were equally interesting. At a concentration of 39.25 mg. per liter, for example, the wireworms were inactive at the end of the 5-hour exposure period; 24 hours later 17 were inactive and 8 appeared dead; 72 hours after exposure 4 were able to walk, 10 were inactive, and 11 appeared dead; 1 week after exposure 6 were inactive and 19 appeared dead; 10 and 15 days after exposure 3 were inactive and 22 appeared dead; 1 month after exposure 5 were able to walk, 2 were inactive, and 18 appeared dead; and 2 months after exposure 3 were able to walk and 22 were dead and had decomposed. The most remarkable thing here is the fact that at least 2 of those that appeared dead 15 days after exposure were able to walk 15 days later. After such an experience as this in some of the preliminary experiments, none of the larvae were ever called dead until they had decomposed. The writer (2) had a similar experience with paradichlorobenzene. It is the writer's opinion that most investigators of fumigants do not keep the test insects long enough after exposure to determine definitely whether they are actually dead or merely anesthetized.

TABLE 1. MORTALITY OF WIREWORMS RESULTING FROM EXPOSURE FOR 5 HOURS TO VARIOUS CONCENTRATIONS OF DIFFERENT FUMIGANTS AT A TEMPERATURE OF 25°C. (77°F.) AND A RELATIVE HUMIDITY OF 80 PER CENT

Fumigant	Formula	Concentration of fumigant Mg.	Wireworms killed by fumigant* Per cent
Carbon disulfide	CS_2	23.70	42.9 (41.6)
		27.74	37.1 (40.3)
		31.50	50.0 (54.6)
		35.44	84.3 (87.0)
		39.50	90.0 (94.8)
		43.18	100.0 (100.0)
		47.17	97.0 (100.0)
		51.03	100.0 (100.0)
		54.95	100.0 (100.0)
		59.15	100.0 (100.0)
Chloropicrin†	CCl_3NO_2	.17	15.0 (12.5)
		.35	20.0 (8.3)
		.51	30.0 (16.7)
		.69	50.0 (58.3)
		.86	95.0 (95.8)
		.86	100.0 (100.0)

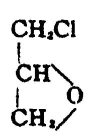
Methyl cyanide	CH_3CN	6.12	.0
		36.70	.0
		48.94	28.6
		64.22	76.2
		73.52	85.7
		85.64	100.0
		97.88	100.0
Allyl isothiocyanate‡	CH_2:CH.CH_2NCS	.10	4.2
		.13	33.3
		.16	41.7
		.18	79.2
		.21	95.8
		.21	100.0
		.24	100.0
α, β-Dichloroethyl ether	CH_2ClCHClOCH_2CH_3	3.04	36.4
		4.25	81.0
		6.09	91.7
		6.76	91.7
		7.41	100.0
Pyridine	CH$(CHCH)_2$N	4.03	31.9
		7.07	61.5
		8.60	79.5
		11.60	78.1
		12.39	82.9
		13.87	97.4
		14.63	97.4
		14 67	100.0
Ethylene chlorohydrin§	CH_2ClCH_2OH	0.06	17.7
		.25	52.4
		.38	81.0
		.50	76.2
		.63	100.0
		.76	100.0
Crotonaldehyde	CH_3CH = CHCHO	.45	.0
		.67	31.8
		.89	86.4
		1.11	100.0
		1.34	100.0
Epichlorohydrin		.61	19.1
		.92	72.7
		1.23	90.9
		2.44	100.0
Ethylene chloride	CH_2ClCH_2Cl	15.79	14.6
		19.76	26.1
		29.65	76.2
		39.28	100.0
Methyl formate	HCOOCH_3	6.11	15.0
		12.19	47.4
		18.34	95.8
		22.96	100.0
		27.47	100.0

TABLE 1—*Concluded*

Fumigant	Formula	Concentration of fumigant *Mg.*	Wireworms killed by fumigant* *Per cent*
Diethyl carbinol	$(C_2H_5)_2CHOH$	12.86	26.3
		19.10	79.0
		23.14	91.7
		25.63	100.0
β, β-Dichloroethyl ether	$CH_2ClCH_2OCH_2CH_2Cl$	.63	31.8
		1.26	73.7
		1.88	84.2
		2.51	100.0
Ethyl formate	$HCOOC_2H_5$	11.40	15.0
		17.04	52.6
		21.14	76.2
		25.52	95.2
		28.31	100.0

*The mortality percentages were calculated from the number of dead wireworms observed 10 days after exposure except in the tests with carbon disulfide, when the 15-day exposure was used, and with chloropicrin, when the 30-day exposure was used. The numbers given in parentheses in the cases of the tests with these two fumigants are the apparent mortalities obtained at the 10-day exposure.
†10 per cent solution in ethyl alcohol.
‡5 per cent solution in ethyl alcohol.
§10 per cent solution in water.

Some of the fumigants that are shown in this investigation to be much more effective against wireworms than carbon disulfide in air have proved less effective in soil. This subject will be dealt with in a later publication.

TABLE 2. MEDIAN LETHAL CONCENTRATIONS OF THE VARIOUS FUMIGANTS AND THEIR TOXICITY COMPARED WITH THAT OF CARBON DISULFIDE

Fumigant	Median lethal concentration *Mg./liter*	Relative toxicity (CS_2=1)
Carbon disulfide	31.50	1.0
Methyl cyanide	55.82	.56
Ethylene chloride	24.48	1.3
Ethyl formate	16.65	1.9
Diethyl carbinol	15.67	2.0
Methyl formate	12.52	2.5
Pyridine	5.89	5.3
α, β-Dichloroethyl ether	3.41	9.2
β, β-Dichloroethyl ether	.90	35.0
Epichlorohydrin	.79	39.8
Crotonaldehyde	.74	42.4
Chloropicrin	.69	45.9
Ethylene chlorohydrin	.24	131.9
Allyl isothiocyanate	.16	192.9

TABLE 3. MORTALITY OF WIREWORMS FOLLOWING TREATMENT WITH VARIOUS PERCENTAGES OF ETHYLENE CHLOROHYDRIN IN ETHYL ALCOHOL AND IN WATER, THE CONCENTRATION OF ETHYLENE CHLOROHYDRIN BEING CONSTANT AT 0.626 MG. PER LITER

Solvent	Ethylene chlorohydrin in solvent *Per cent*	Wireworms killed *Per cent*
Ethyl alcohol	5	19.3
	10	25.0
	15	30.0
	20	35.0
	25	52.6
	30	73.7
	35	52.6
	40	68.4
Distilled water	5	90.9
	10	85.0
	15	100.0
	20	86.4
	25	100.0
	30	100.0
None	—	84.2
	—	90.0
	—	95.0
	—	86.4
	—	95.5

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AIRPLANE LIQUID SPRAYING

By Frank B. Herbert, *Entomologist, Balfour, Guthrie and Co., Ltd., San Francisco, Cal.*

Abstract

A report on the latest method of applying liquid sprays by airplane. A discussion of types of insecticides and fungicides used, methods of applying, speed, results, advantages, etc. Illustrations.

A new and novel method of applying liquid insecticides and fungicides has been found in the use of airplanes. Although first tried but a year and a half ago this method of application has proven that it undoubtedly has a place in modern science.

Two companies have patented applicators and have treated a total of more than two thousand acres of various crops with satisfaction.

History of Development.—The Hawke Crop Dusting Company was the first to develop a liquid applicator for airplanes. In this they used the exhaust of the motor to break up and distribute the spray, but this was not satisfactory and was abandoned as its volume was too small and the heat was dangerous.

Next the Independent Crop Dusting Company invented a steel bristle rotary brush driven by a small propeller. The spray oil flowed by gravity to the center of the brush, centrifugal pumps forcing it out through spacers to the bristles which upon rotating broke the material into a fine fog. See Plate 51, Figure 1.

In the meantime the Hawke Company had invented another type which used propeller blades instead of brushes. The material flowed by gravity into the hollow three bladed propellers and through jets set in small venturi tubes near the tips of the blades. Between the centrifugal force and the speed of the propellers this device also broke the oil into a fine fog. See Plate 51, Figure 2.

Both types of "rotors" are now in use and have proven very satisfactory.

Method of Application.—The concentrated oil is applied using air as a carrier instead of water. The oil is made miscible so that it will not be repelled by the moisture it may contact and to give greater creeping power.

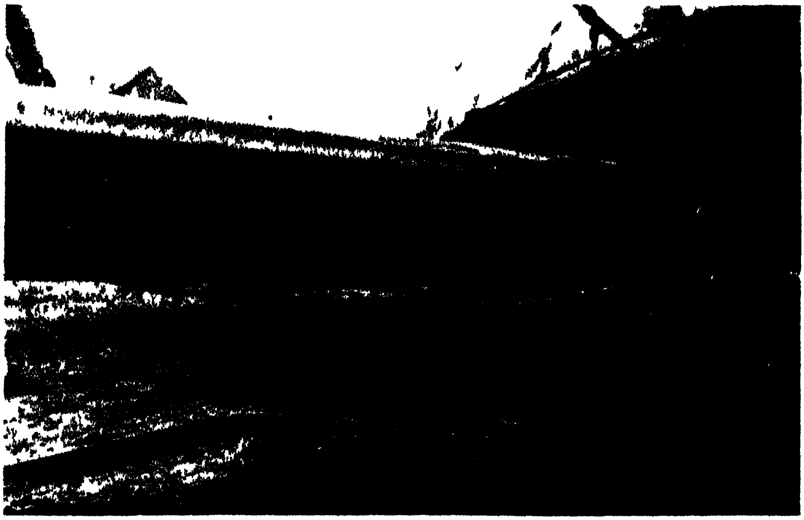
Oils seem to be essential as water solutions evaporate before contacting the plants. These oils may be used for scale control or may carry other insecticides such as nicotine or pyrethrum or oil soluble fungicides.

Capacity.—The planes travel from 80 to 110 miles per hour and the rotors are capable of throwing out the spray at the rate of 5 to 80 or 100 gallons per minute, depending upon the amount required.

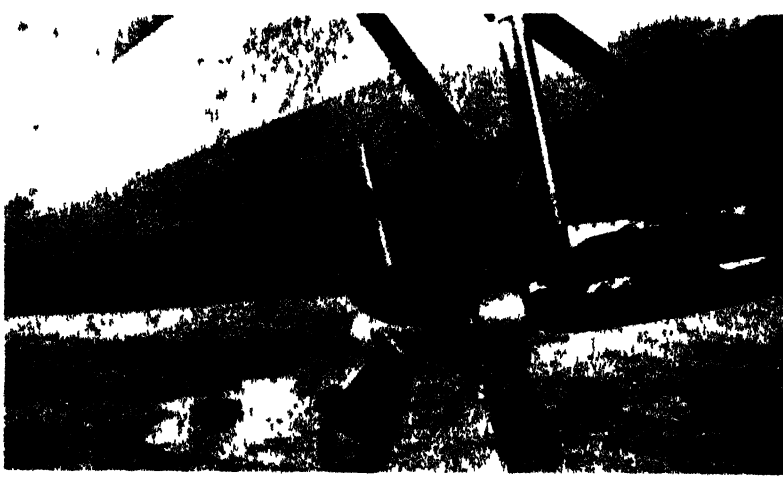
1. Hawley Crop Dusting Company plane applying Dormant Soluble Oil on [illegible] for scale control on the [illegible] orchard at San Jose, California.

2. Planes loading Nicotine for Peach Twig Borer Control on the Marsh Ranch at Brentwood, California. *All photos by Author.*

Plate 51



1 The Independent Crop Dusting Company's rotor There is one on each lower wing of the plane



2 The Hawke Crop Dusting Company's "rotor" The plane is equipped with two "rotors" each connected to the struts under each wing

1 Plane applying Vapona for grape Leafhopper control on American Seedless Vineyard at Del Rey, California

2 – Leafhoppers from half a vine, knocked down and killed by the above treatment

Plate 53

1 Plane carrying Vapora for control of onion thrips on onions at Waldo Rohnert Seed Company's Ranch Walnut Grove California

2– Plane applying Miscible Nicona for pear thrips on prunes on G. C. Bouret orchard San Jose California

The planes are able to distribute from 2 to 15 gallons per acre so evenly that there is little danger due to too much material concentrating in any one spot. From four to ten gallons are normally required per acre.

In orchard practice the plane usually sprays one row at a time. With vineyards or truck crops they cover a width of 30 to 40 feet at each trip. With either type of crop the plane flies at a height of 2 to 4 feet above the top of the plants, occasionally touching those that stand above the others.

TIME REQUIRED.—Individual acres have been covered in seven seconds, while single loads, which usually consist of 100 to 110 gallons, have been sprayed out in 11 to 20 minutes, covering 15 to 20 acres. Taking into account loading, each plane can apply the spray on 35 to 60 acres per hour. Loading is usually done in about 2 minutes, using rotary pumps driven by auto motors or batteries. These throw 50 to 60 gallons per minute

COVERAGE.— The oil is broken into a fine fog floating in the air similar to dust It floats downward as the plane compresses the air below it and then rebounds while the wash of the plane starts it rolling. The material can be seen spreading laterally for 40 to 75 feet from the center of the plane.

The trees or plants receive a heavier film of oil on the upper surface but many tiny droplets of oil can be found on the lower surface if examined microscopically. These slowly diffuse to give a satisfactory coverage. The oil on the upper surface of the twigs and branches creeps around them to aid in coverage.

ADVANTAGES —Spraying by plane has the following advantages:

Speed Large acreages can be covered at the right time giving better control. Many pests such as brown rot, scab, leaf curl, leaf hoppers, thrips and aphids require treatment within a short period of time.

Wet ground. Irrigation checks may be left up, the ground may be wet or irrigation may be under way while airplanes are applying the spray. The ground is not packed by heavy equipment.

Ground Cover. Many crops like onions, peas, beans, cotton and melons cover the ground so that any equipment except airplanes would ruin a considerable portion of the crop.

Materials more potent. The sprays, especially nicotine and pyrethrum are much more potent in the concentrate form as applied by planes.

No loss from wind. Oils when once applied to a surface will not be blown off by wind as is the case with many of the dusts.

Less Equipment. Large ranches find it costly to maintain spray equipment and rolling stock to treat their crops at the proper time By hiring planes there is a considerable saving Planes can compete economically with most ground equipment

LIMITATIONS.—Planes are handicapped by windy weather more so than ground equipment, although this is made up for by the greater speed of the plane In one hour a plane can cover as much ground as a spray rig can in 2 to 4 days

There is still some question as to whether a plane can cover trees with heavy foliage such as citrus

COSTS —Materials applied by plane are generally of higher grade than those applied from the ground, hence cost a trifle more per gallon This is often offset by the fact that the plane applies a smaller gallonage per acre.

The cost of application for most acreages is 30 cents per gallon This is reduced to 25 cents for runs a mile or more long This is cheaper than most ground work in spite of the present low cost of labor

PESTS TREATED —Table No 1 gives a list of many of the pests treated by plane.

TABLE 1 PESTS TREATED BY AIRPLANE

Pest	Host plant	Acres treated	Material used	Gals per acre
Bud Mite	Pears	5	Dormant Soluble Oil-Tox	10
Peach Blight	Peaches	364	Miscible Coprol	6
	Nectarines	17	Miscible Coprol	6
Shot Hole Fungus	Apricots	10	Coprol	8
Brown Apricot Scale	Apricots	20	Dormant Soluble Oil	6 to 10
Brown Apricot Scale, Twig Borer, Brown Rot	Apricots	16	Coprol No 2	5 to 9
Brown Apricot Scale	Prunes	20	Dormant Soluble Oil	10
Peach leaf curl, Twig borer	Peaches	120	Coprol No 2	6
Brown Rot, Twig borer	Apricots	10	Coprol No 2	6
Twig borer	Peaches	43	Nicona No. 2	6
		159	Arsona No. 2	6
	Nectarines	39	Nicona No 2	6
Pear Thrips	Prunes	280	Miscible Nicona	5 to 7
Calico Scale	Walnuts	17	Dormant Soluble Oil	9 to 18
Pear Scab	Pears	50	Miscible Funjona	8
Leaf Roller, Twig Borer	Apricots	106	Nicona No. 2	7–8
		85	Arsona No. 2	6–8

MATERIALS REQUIRED.—In explanation of the materials used, Dormant Soluble Oil is a winter type Miscible Oil Dormant Soluble Oil

Tox contains certain toxics which aid in penetration and kill of bud mites, armored scale insects, etc.

Miscible Coprol and Miscible Funjona are winter and summer forms of oils containing fungicides. Coprol No. 2 differs in also containing an arsenical.

Miscible Nicona is a miscible summer oil containing nicotine. Nicona No. 2. also contains an arsenical. Arsona No. 2. is a summer oil containing basic lead arsenate. Vapona contains pyrethrum and nicotine in light oil.

Airplane spraying requires many materials and combinations for the control of various pests. As the planes contain no agitators these combinations can not be mixed in the field, but must be combined in the factory so as to assure satisfactory solutions or suspensions. Balfour, Guthrie & Co. is the first manufacturer to design and register materials especially for airplanes. Most of these are also satisfactory for ground machines.

RESULTS.—There was some variation in the control obtained, but the results were far above all expectations. They were fully as satisfactory as ground application. The fungicides applied in the fall not only controlled peach blight but leaf curl as well. The Coprol applied to apricots for shot hole fungus also killed leaf roller eggs.

The Miscible oil applied on prunes and apricots during the dormant season for brown apricot scale showed almost 100 per cent control. This is proof of coverage as all of these scales are found along the under side of the twigs. Several days after application one could lift up the dying scales and find them sitting in a ring of oil.

Thrips control was highly satisfactory. One grower reports that not a single prune was scarred this year, while he sorted out many that were scarred last year. Many of his neighbors are now having to spray for mealy plum lice while none have appeared on his 60 acre orchard to date, this having been a serious problem with him last season.

The control of brown apricot scale with oil and nicotine when spraying for thrips, appears so complete that several growers already plan to leave out their winter scale spray next season and depend on the thrips spray only.

The grape leaf hopper overwintering adults were nicely controlled on the vines by airplane using 4 gallons of Vapona per acre. This will have to be increased slightly for nymphs to be sprayed in June to account for the extra foliage.

POSSIBILITIES.—The results to date indicate that there are many pests that can be satisfactorily controlled by the use of airplanes, many

of them better than with ground machines. As crops become of greater value, still greater interest will be shown in this type of spraying. Growers with large acreages are already finding the plane of great use, especially during wet seasons.

Epidemics where speed is the essential requirement will find planes bearing the brunt of the battle.

Preliminary work is now being done on onions for onion thrips, which indicates they will be controlled by plane more satisfactorily than with any other method.

A PRACTICAL TEST OF CHEMICALLY TREATED BANDS FOR THE CONTROL OF THE CODLING MOTH

By E. J. Newcomer, A. R. Rolfs, and F. P. Dean, *U. S. Bureau of Entomology*

Abstract

Chemically treated bands were tested during three successive seasons. In spite of severe infestations, the increase in the wormy (*Carpocapsa pomonella* L.) fruit was only 72.5 per cent in the banded block, as compared with 204 per cent in two blocks not banded but sprayed the same. It was estimated that an average of about 50 per cent of the worms leaving the fruit were caught in the bands.

A great deal of experimental work has been done with bands treated with various chemicals for killing the larvae of the codling moth (*Carpocapsa pomonella* L.). There have been many papers published giving results in terms of relative numbers of larvae caught, and percentages of larvae killed. These results have shown that treated bands are fully as attractive to the larvae as untreated bands, and that the chemicals used are, for the most part, extremely effective in killing the larvae. The writers have not been able to find any publication giving the practical results of banding, in terms of percentage of wormy or of sound fruit, and it is the purpose of this paper to present data of this nature.

In 1930 a rather wormy orchard was selected for spraying experiments, in the Yakima Valley of Washington. This orchard consisted of alternate double rows of rather large Jonathan and Winesap apple trees. A dozen or more different spraying treatments were outlined, and four of these were chosen, each of which was to be used in four different places in the orchard. Accordingly, four blocks of 64 trees each were chosen, each block being divided into smaller blocks of 16 trees, and one of the four treatments was used in each of these four smaller blocks. There were thus 16 subplats, each of which contained both varieties of apples.

The schedule included a calyx spray and six cover sprays, and the treatments were as follows:

1. Lead arsenate, 2 or 3 pounds to 100 gallons.
2. Lead arsenate, plus three-fourths of 1 per cent mineral oil emulsion in 2 sprays.
3. Lead arsenate, 5 sprays; nicotine sulfate, 1–1,200, plus three-fourths of 1 per cent mineral oil emulsion, for the last 2 sprays.
4. Lead arsenate, first 2 sprays; followed by barium fluosilicate or cryolite used with fish oil or mineral oil emulsion.

This schedule was adhered to for three seasons, and while there was some variation in treatment from season to season, there was no variation in the different subplats in a single season.

One block of 64 trees, including all four treatments, was banded annually for the three seasons. This will be called the B block. Blocks A and C were not banded at all, and block D was not banded in 1930 or 1931, but the trees were scraped in the fall of 1931 and banded in June 1932. All banded trees were thoroughly scraped, and bands treated with the usual mixture of beta naphthol and oil were used. Fresh bands were applied each year. No injury to the trees from the use of these bands was noted.

In order to learn the effect of this banding, all of the fruit from 16 trees in each block of 64 trees was examined each season. This included 4 trees, two of each variety, in each of the 16 subplats. Over 100,000 apples from the 64 trees were examined each year. The results of this examination are shown in the following table:

Blocks	Treatment	Apples wormy (Per cent) 1930	1931	1932	Increase over 1930 (Per cent) 1931	1932
B.	Banded 3 years	11.6	12.8	20.0	10.4	72.5
D.	Banded in 1932 only	13.0	27.7	30.2	113.0	132.0
A & C.	Not banded.	11.0	22.5	33.5	105.0	204.0

The seasons of 1931 and 1932 were extremely favorable to the development of the codling moth, and there was a general increase in infestation throughout the State. In blocks A and C, in spite of a heavy spray schedule, the percentage of wormy fruit had more than tripled in the three years. In the banded block B, on the other hand, the percentage in 1932 had shown an increase of only 72.5 per cent over 1930. In block D the increase in 1931 was somewhat greater than in blocks A and C, being 113 per cent as compared with 105 per cent. This block was banded in 1932, and at the end of the season it showed an increase of only 132 per cent over 1930, as compared with 204 per cent in the blocks

not banded. It was actually less wormy than the unbanded blocks in 1932, although it had been wormier in 1931.

These results show quite conclusively that banding is a very valuable adjunct to the usual spraying treatment. Each of the banded blocks, B and D, had an area of only about one acre, and the writers believe that if a larger area had been banded, the results would have been even more striking.

In order to find out what proportion of the larvae were caught in the bands, records were made in 1931 and 1932 of the number of larvae that had left the fruit on certain banded trees at the time the fruit was picked and removed from the orchard. This number was compared with the number of larvae found in the bands on those trees. In 1931 the fruit from 7 trees was examined, and of 465 larvae that had left the apples, 156, or 33.5 per cent, were in the bands. In 1932 the fruit of 15 trees was examined, and of 961 larvae that had left the apples, 654, or 68 per cent, were in the bands The percentage will undoubtedly vary considerably, owing to differences in the thoroughness of scraping the trees, differences in the trees themselves, in the time of picking, and in the promptness of removing fruit from the orchard, but it may be assumed from the above figures that approximately 50 per cent of the larvae leaving the apples should be caught in the bands.

Incidentally, it was found that only about 20 per cent of the larvae had left the apples when the Jonathans were picked in September, and 35 per cent when the Winesaps were picked in October This indicates the very great desirability of prompt removal of all apples from the orchard when picked, and the prompt use or destruction of all wormy apples.

SOME NOTES ON THE BIOLOGY OF THE PEA WEEVIL *BRUCHUS PISORUM* L. (COLEOPTERA, BRUCHIDAE) AT MOSCOW, IDAHO

By T. A. Brindley, *Assistant Entomologist, Bureau of Entomology, United States Department of Agriculture*

Abstract

The hibernation, egg deposition, life cycle, and the length of life of the pea weevil are discussed.

Recent experiments on the control of the pea weevil, *Bruchus pisorum* L., have necessitated additional work on the biology of this pest. In the course of these studies some additional information, not now contained

in the literature concerning the insect, and some which seems to add to that already existing, was accumulated. This information is presented here.

HIBERNATION.—The weevil has been variously reported as spending the winter in the peas (1), in rubbish and out buildings (4), and in lichens and under the bark of several kinds of trees (2). In this part of the country all the individuals that can escape from the peas seek shelter under the bark of pine trees, in old buildings, and in the debris on and about the pea fields.

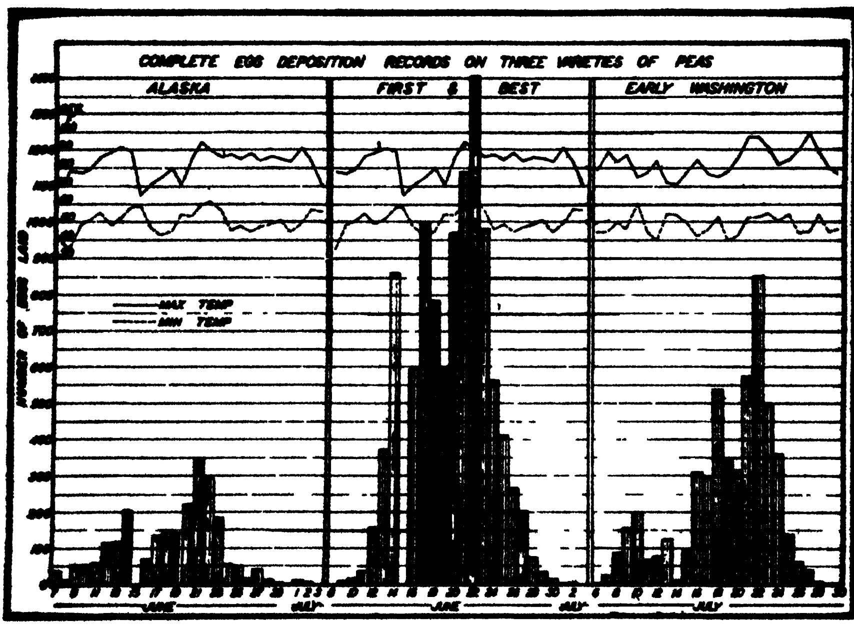


Fig. 90.—Complete records of egg deposition by pea weevils on three varieties of peas.

The shelter afforded by the trash and debris on the pea field after harvest was especially interesting. Eight individuals were collected in a cage covering 12 square feet of a field's surface, and a like number might have been taken elsewhere on the field, for the cage was put out in the spring and was located by chance. Such a survival under the refuse on the field may account for the large populations of pea weevils which appear each spring in certain areas about Moscow, Idaho.

The weevils emerge from hibernation about the time the peas bloom, but they do not appear on the vines in large numbers until shortly after blooming begins. On one patch of volunteer peas which was in blossom

on June 5, 1932, seven weevils were collected in 100 sweeps with a 15-inch collecting net. Five days later, however, 1,096 weevils were collected on the same peas in an equal number of sweeps.

OVIPOSITION.—The insects, after locating the pea vines, feed for about a week on the pollen of the pea flower, after which the weevils mate and lay eggs. Pollen food of some kind is necessary before the weevils are able to lay eggs. The small, bright orange colored eggs are laid on pods of all sizes, varying from those still covered by the corolla of the pea to those that have begun to harden. Pods which have nearly reached their maximum size but are still succulent are preferred. The number of eggs laid on each pod depends, largely, on the extent of the infestation. The greater the number of weevils present, the greater the number of eggs that will be laid on each pod. As high as 126 eggs have been laid on a single pod in this district. Eggs have been found on practically every part of the pea pod and flower.

A study of the egg deposition on over 750 pods showed them to be suitable for oviposition for as long as 18 days. Pea plantings as a whole were found to have pods suitable for oviposition for a maximum of 25 days (Fig. 90).

Contrary to the results of other workers (1) and (3), the insect was found to lay a very large number of eggs. A maximum of 735 was recorded, with a minimum of 92 and an average of 432, for the 12 pairs studied (Table 1). The records were obtained by placing a fertilized female in a test tube which had been provided with a pod for egg laying and blooms for food. Each day the eggs were counted and a new pod and blossoms were provided.

TABLE 1. SUMMARY OF THE DAILY EGG DEPOSITION OF 12 PAIRS OF PEA WEEVILS, AT MOSCOW, IDAHO, 1932

	Number of eggs laid	Deposition period in days
Maximum	735	84
Minimum	92	21
Average	432	56
Maximum for 1 day	56	1
Minimum for 1 day	0	1

LIFE CYCLE.—When the egg of the pea weevil hatches, the young larva bores directly through the chorion of the egg at the point where it is attached to the pea pod into the pod, and then into the pea. Often the weevil does not make its way directly into the seed, but mines about in the wall of the pod before entering the interior and penetrating a seed. Several larvae often enter the same seed, but only one adult has been observed to emerge. Many cases have been observed where two insects

have reached the adult stage, but only one emerges alive, for the slower developing individual, while it is still in the larval stage, kills the first formed adult. Table 2 shows the development of the larvae by instars, as found by splitting infested peas at 2-day intervals throughout the larval period.

TABLE 2. DEVELOPMENT OF THE LARVAE OF THE PEA WEEVIL BY INSTARS AT MOSCOW, IDAHO (1932)

Date	Number of larvae of each instar				Daily head-capsule measurements in mm.		
	1st	2nd	3rd	4th	Average	Maximum	Minimum
June 28	25				0.1367	0.1430	0.1287
30	25				.1338	.1430	.1287
July 2	25				.1436	.1716	.1287
4	25				.1493	.1573	.1287
6	24	1			.1468	.1573	.1287
8	25	0			.1578	.3718	.1287
10	14	11			.2593	.3888	.1287
12	2	21	2		.3512	.3861	.1287
14	8	15	2		.2938	.6480	.1287
16		9	16		.5189	.6578	.3146
18		7	18		.5472	.6768	.3024
20			25		.6395	.6730	.6006
22			25		.6581	.6912	.6048
24			24	1	.6484	.9370	.5863
26			25	0	.6470	.7668	.6336
28			25	0	.6412	.7150	.5720
30			19	6	.6973	1.0224	.5904
Aug. 1			11	14	.8107	1.0224	.5720
3			15	10	.7410	.9798	.5328
5			12	13	.7774	.9372	.5472
7			7	18	.8313	.9372	.5900
9			3	22	.8724	1.0224	.5964

Average head-capsule measurements—first instar, 0.1420 mm.; second instar, 0.3458 mm.; third instar, 0.6353 mm.; fourth instar, 0.9125 mm.

Table 3 gives a summary of the length of the different stages in the life cycle of the insect. These data were obtained by splitting peas at 2-day intervals.

TABLE 3. SUMMARY OF LIFE-HISTORY DATA ON 400 PEA WEEVILS REARED IN FIRST AND BEST PEAS AT MOSCOW, IDAHO, 1932

Stages	Length of the stages (in days) Maximum	Minimum	Average	Standard deviation	Modal class
Egg	13	6	8.7	1.46	9
Larva	56	28	41.7	3.48	41
Pupa	18	10	13.7	1.07	14
Life cycle	82	50	64.1	4.04	65

In the fall, when the peas are ripe, the adults emerge and seek hibernation quarters. Fig. 91 shows the development of the pea weevil and its

relation to temperature and rainfall. The emergence of the weevils in the fall proceeds gradually until a rain, after which they emerge in large numbers.

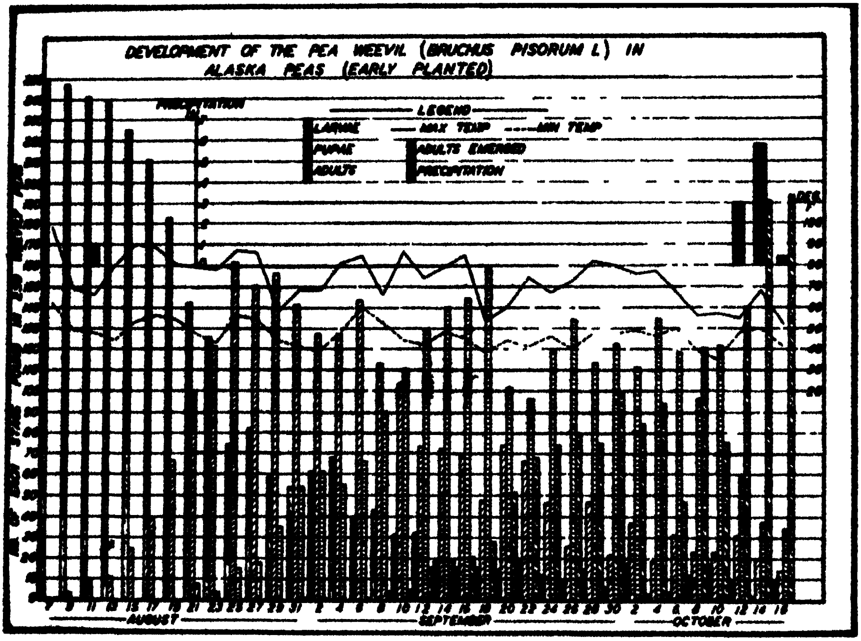


Fig. 91.—Development of the pea weevil (*Bruchus pisorum*) in Alaska peas in 1932.

LENGTH OF LIFE.—The length of life of the insect is much greater than any reported in the literature. On May 28, 1933, 11 per cent of the weevils in the peas of the 1931 crop were still alive. It seems entirely possible that some of these individuals will produce eggs this crop season.

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THE LOCAL DISPERSAL OF THE PEA WEEVIL

By A. O. LARSON, T. A. BRINDLEY, and FRANK G. HINMAN,
Bureau of Entomology

ABSTRACT

Pea weevil (*Bruchus pisorum* L.) infestation varies greatly in different parts of the same field; the greatest number of adult weevils and the heaviest infestations of the growing peas are usually found on the edge nearest the source of infestation, near hibernation quarters, and in the hollows and swales.

The habits of the adult pea weevil (*Bruchus pisorum* L.) in connection with its dispersal offer an interesting problem, the solution of which may suggest a possible means of control. A study of the dispersal of the pea weevil must of necessity include the sources from which it escapes as well as its methods of overwintering and of reaching the new crop.

This insect has only one known host plant, but this one host, the many varieties of peas, provides several sources from which the weevils may escape. These sources are: (1) seed peas which are imported without proper fumigation, (2) peas left on the vines after the main crop has been harvested, (3) peas which, because of disease or other unfavorable conditions, have been left unharvested, (4) peas which have been grown for hay, (5) volunteer peas which are not harvested, (6) the main crop of peas improperly fumigated or not fumigated at all, (7) screenings cleaned from the main crop of peas, and (8) all peas wasted in the process of harvesting and cleaning the crop. A program of control should consider all of these sources. The importance of some of these sources has been pointed out in an earlier paper (2).

The pea weevil has only one generation a year and spends the winter in the adult stage, either within the pea or in some other suitable place. Soon after the peas are ripe the earliest maturing weevils emerge from them. Other weevils emerge during the next few weeks, or, if the peas are not disturbed, may remain in a semi-dormant condition within the peas during the entire winter or longer. Those weevils which remain within the peas can be easily destroyed, but those which escape cause the greatest problem. It has been pointed out (2) that more than a million pea weevils may be liberated from the shattered peas lost in harvesting one acre of Austrian winter field peas.

The weevils which emerge in the fall fly about during the warm part of the day until they find suitable hibernating quarters. Shortly after harvest the weevils in badly infested fields can be seen flying about in all directions. When the temperature drops in the evening the weevils seek shelter in straw or rubbish on the ground, if they have not already found

more favorable locations. Flights occur day after day until a suitable hibernating place is found. Their search for winter quarters is hastened by rainstorms which cause most of the weevils remaining in the peas on the ground to emerge and seek shelter.

It is not known just how far the pea weevil can fly but observations indicate that it probably can travel several miles Korab (1) liberated marked weevils in the spring and later found several of them on peas more than two miles away. The outskirts of a town and a large area of wooded land lay between the point of liberation and the point at which they were recaptured. Five counts made by the writers in different places on one field indicated that it was about 80% infested, yet this was the first year that field peas had been raised in this neighborhood The only accountable source of infestation was from a field a mile away and from another more than two miles away on which peas had been grown the year before

The weevil hibernates in cracks in fence posts, under the bark of trees, in moss and lichens on trees, in the pine duff under pine trees, and in numerous other places Hibernation of the pea weevil has been discussed in an earlier paper (3)

The writers have been collecting insects from flight traps in various parts of the Willamette Valley of Oregon over a period of two years. During this time pea weevils have been collected from these traps in every month of the year, but not in all the months of either year This shows that in Oregon they fly to some extent during warm periods in winter In Northern Idaho, where the winters are colder, we have not found that they fly during warm periods

After a few warm days in spring the weevils fly from their shelters and alight on weeds and grasses about their hibernating quarters. They may often be found hiding between a grass blade and leaf sheath A little later they migrate to the pea fields. Some peas were examined on the afternoon of April 28, 1932 but no weevils were found, although they were numerous on some grasses not far away. By noon of the day following, however, many of them had migrated to these peas.

In badly infested areas the casual observer might fail to see the weevils in a field of peas just beginning to bloom, but a more careful examination would reveal many of them hiding between partly developed leaves. Later, as the weather becomes warm and the flowers appear, the weevils may be seen making short flights from blossom to blossom, or they may be found hiding inside the pea flowers or crawling actively about over the vines. On cold days they remain in hiding within the blooms or within the partly opening leaf buds.

The number of pea weevils may vary greatly in the different parts of the same field. They usually occur in greatest numbers nearest the source of infestation. This was shown very strikingly by sweeping around the edge of a 48-acre field of blossoming peas. The north and west sides of this field adjoined open fields and along these sides an average of 13 weevils and of 50 weevils, respectively, were obtained per 100 sweeps of a collecting net. The south and east sides jogged irregularly, almost forming the hypotenuse of a right-angled triangle. This long, irregular side adjoined a heavy growth of forest trees at one end and trees and a barnyard at the other. Along this side an average of 550 weevils were collected per 100 sweeps. This field had produced a crop of peas the preceeding year and the weevils which had emerged from the shattered peas left on the field had found an abundance of hibernating quarters in the adjoining trees.

In Western Oregon woods adjoin many of the pea fields on all sides. Other fields are bounded by hedges of wild rose and other bushes interspersed with oak, or fir, or other trees which provide shelter for hibernating pea weevils. In such fields the weevils are found most abundantly near the edges. As an illustration of this unequal distribution, sweepings were made about a thirty acre field of blossoming peas, 1240 in going around the edge of the field and an equal number of sweeps 40 to 60 feet in from the edge. 475 weevils were collected; 81 out in the field a short distance, and 394, or nearly five times as many, along the edge.

Table 1 presents a study of the weevil population in a 25-acre field of

TABLE 1. WEEVIL POPULATION AND INFESTATION STUDIES ON AN EARLY PLANTED FIELD

	Date sweepings were made (1)															Weevil examinations (2) (% weevily)		
	6/7			6/10			6/16			6/22			7/1					
	Edge	50 ft. in	Center	Edge	50 ft. in	Center **	Edge	50 ft. in	Center **	Edge	50 ft. in	Center **	Edge	50 ft. in	Center **	Edge	50 ft. in	Center
	0	*	*	51	21	8	162	50	29	82	147	13	0	1	2	63.6	71.2	6.0
	0			12	4		302	17		144	172		0	0		74.4	55.8	3.4
	0			6	4		555	59		573	547		16	0		78.6	76.9	7.4
	0			15	1		412	35		257	278		14	2		85.2	57.8	
	1			24	0		230	87		111	175		12	4		87.8	32.9	
	0			20	0		156	39		48	100		43	0		73.6	34.6	
	0			65	5		156	15		68	14		3	3		69.0	12.0	
	1			34	6		159	26		85	21		2	1		64.2	17.4	
Ave.	1			28	5	3	267	41	9	171	182	4	11	1	1	74.5	44.8	5.6

(1) Figures indicate the number of weevils per 100 sweeps of a 15″ collecting net.
(2) Five hundred peas examined.
*No sweepings made.
**Three hundred sweeps taken.

Alaska peas at different dates while the peas were developing. Weevils were collected at the edge of the field, 50 feet in from the edge, and at the center. About 28 times as many weevils per 100 sweeps were collected at the edge of the field as were found in the center. This table also shows the per cent of weevil infestation found after harvest in the peas picked up where the collections had been made. The peas at the edge of the field were about 13 times as heavily infested as those in the center of the field.

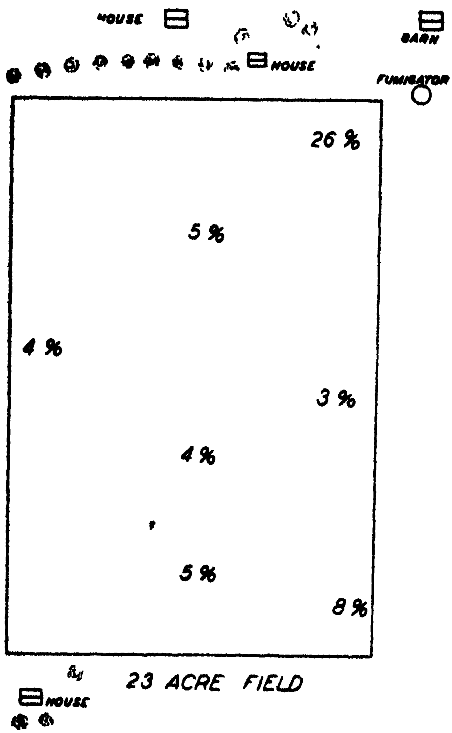

Fig. 92.—Pea weevil infestation in a 23-acre field after harvest.

In the vicinity of Moscow, Idaho, where the pea fields occur on rolling or hilly ground and where hibernation conditions are somewhat different, the greatest number of weevils is generally, but not always, found near the edges of the field. In this section it has been noted that a heavier infestation of weevils is to be found in the swales or hollows than can be found on the ridges or level areas adjoining. Moderate to heavy westerly winds prevail. The pea weevils appear to congregate in the shelter afforded by the low places. In this connection we have found it to be almost invariably true that high points are less infested than low ones. This holds in general without reference to their nearness to the borders of the field.

Table 2 shows the variation in the per cent of weevil infestation found on the hills and in the valleys of one field. The greatest infestation (90%) was in the valley at the edge of the field, while the smallest infestation (12.3%) was on the ridge only 300 feet from the border. The infestation in the valleys was twice as great as the infestation on the ridges.

After harvest the writers have picked up the shattered peas on measured plots in order to get estimates of crop loss and per cent of weevil

infestation. The samples thus collected have invariably shown an uneven distribution of infestation.

TABLE 2. VARIATION IN THE PER CENT OF WEEVIL INFESTATION OF PEAS GROWN ON HILLS AND IN VALLEYS IN THE SAME FIELD

Location of parallel ridges and valleys	Distance from east end of field 0 feet	300 feet	600 feet	1400 feet	Averages
North side in valley	74.0%	81.0%	77.0%	69.5%	75.4%
Ridge parallel to north side	49.5%	55.2%	23.5%	25.0%	38.3%
Valley through center of field	49.5%	64.5%	70.0%	63.2%	61.8%
Ridge parallel to valley	49.5%	12.3%	15.8%	34.0%	27.9%
Valley along south side	90.2%	42.0%	53.5%	61.5%	61.8%

Figure 92 shows the infestation found in a 23-acre field with hibernating quarters at both ends of the field. Here the infestation varied from

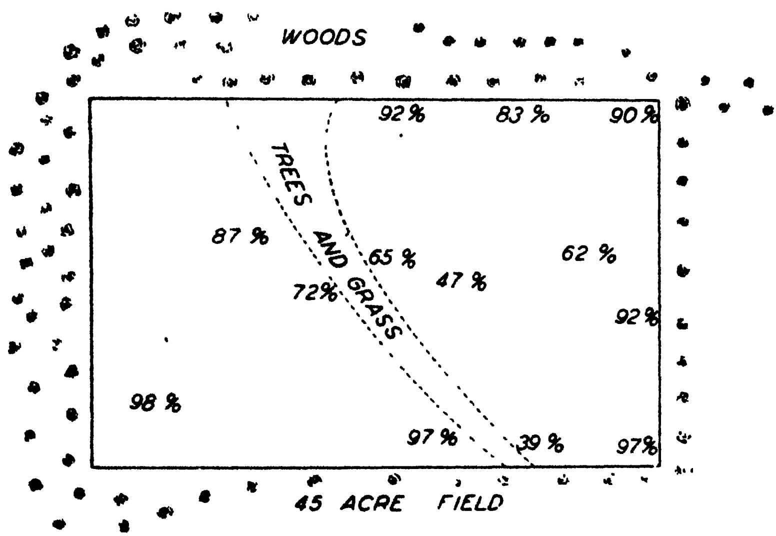

Fig. 93.—Pea weevil infestation in a 45-acre field surrounded by woods.

4 to 26 per cent in different places, being greatest near these hibernating quarters.

Figure 93 shows the infestation in a 45-acre field which was surrounded by woods. Although this was only the second crop of peas, it was heavily infested.

Any section of a field bearing a light stand of peas will usually be found to be heavily infested. This is probably because that section harbors as many weevils as the area about it but not as many peas. Any part of a field left unharvested because the weeds are thick or because the plants are thin will usually furnish a large number of weevils to infest the next year's crop.

The variation in infestation in the different parts of a field depends, to a considerable extent, on the size of the field. The infestation in a large field may be very great in one section and very small in another, while a smaller field would not exhibit this extreme range, and a very small field would contain nearly the same number of weevils throughout its area.

The unequal infestation at harvest time shows that the weevils remain unevenly distributed until after most of their eggs have been deposited. After the blossoms have disappeared and the pods have begun to dry up there is another dispersal of the weevils. They then appear to be more generally distributed over the entire field as well as over weeds in fields and pastures adjoining. This dispersal is caused by a shortage of food. At such times we have found them feeding on the pollen of numerous wild flowers. One weevil was found more than half a mile from the nearest pea field. By the time the peas are ready to harvest in Western Oregon the adult weevils have all left the fields. Here we have been unable to find that any of them return to hibernation. They appear to leave the drying pea plants in search of food and soon die.

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TEMPERATURE AS A POSSIBLE LIMITING FACTOR IN THE NORTHERN SPREAD OF THE COLORADO POTATO BEETLE

By G. Allen Mail and R. W. Salt[1]

Abstract

The history of the spread of the Colorado Potato Beetle (*Leptinotarsa decemlineata*) from its native home is briefly reviewed. Data show that the lethal undercooling points of 80 individual beetles ranged from minus 4.3 degrees Centigrade to minus 11.6 degrees Centigrade. The influence of hibernation depth and the probable effect of winter soil temperatures on hibernating beetles is discussed. Data are presented to show the protective influence of a snow covering and some temperature data are tabulated from the Beaverlodge Experimental Station, in the Peace River district of Northern Alberta in an attempt to explain the absence of the beetle in that area, where its native food plants abound.

[1]Contribution from Montana State College, Agricultural Experiment Station. Paper No. 34 Journal Series.

The Colorado Potato Beetle was first found by Thomas Say in Colorado in 1820 on his first Western trip. It was at this time, according to Tower (1906), sparsely distributed over the eastern slope of the Rocky Mountains, then, as now, feeding on the native Solanaceous plants. During the period from 1855 to 1874, due to the western extension of human colonization and the introduction of a new food plant in the cultivated potato, the beetle quickly spread from its relatively restricted habitat, the Rocky Mountain Region, to the Atlantic States.

The two chief barriers to the northward spread of the potato beetle in its wild state were probably food plants and winter temperatures. The northern limit of its original habitat is not clearly known, but was probably in the region of the present international boundary. Two at least of its native food plants, *Solanum triflorum* and *S. rostratum* were indigenous to this district so that insofar as food is concerned its presence in Northern Montana may be assumed

During its eastward progress it was spreading also north and south, the earliest record of its appearance in Canada being by Bethune (1874) who notes its appearance in Ontario in 1870. It made its appearance in New Brunswick in 1878, was reported from Manitoba in 1879, and in Nova Scotia in 1881. The first definite record of the potato beetle in Western Canada would appear to be in 1899, in Alberta, presumably the extreme southern part of that province, and Gibson et al (1925) mention its appearance in Pincher Creek and Calgary in Alberta, and Moose Jaw, Saskatchewan in 1901. By 1910 it was in the neighborhood of Edmonton, just south of Latitude 54°. In 1927 H. L Seamans in correspondence stated "The beetle occurs at least 100 miles north of Edmonton" where it does some damage. It has therefore, within the last 50 years, extended its northward range some 400 miles. Less than 100 miles further north of its present range the potato beetle will strike the well settled and fertile plains of the Grande Prairie and Peace River districts. Over this extensive area the beetle will find food in abundance in the cultivated potato, and winter temperatures will probably prove an important limiting factor in its further spread northward

RESISTANCE OF POTATO BEETLES TO LOW TEMPERATURES.—Considerable experimental work on the effects of low temperatures on the adults of *Leptinotarsa decemlineata* has led to some interesting discoveries. Two of these which concern us here are, first, the wide variability of the undercooling points; and second, the fact that, for this particular insect, freezing is lethal, the undercooling point thus being the minimum vital temperature.

Adults of the potato beetle, upon hibernating in the fall, undergo a

certain amount of hardening. This hardening process is evidenced by a lowering of the freezing and undercooling points, and by a loss in weight. Whether water is bound by the insect is not known. At present we are concerned only with the undercooling points of the insects when in a winter-hardened condition. Artificial hardening of 80 beetles gave a range in undercooling points from —4.3°C. to —11.6°C. with an average of —7.3°C. Salt (1933). These artificial conditions are considered to be fairly representative of natural conditions for two reasons: (1) artificial hardening by exposure to moderately low temperatures has been shown by various workers to duplicate rather well natural winter hardening; (2), it can be shown that the amount of undercooling is not influenced by the rate of cooling within a range of 0.5°C. to 8.5°C. per minute. This range of undercooling temperatures, then, may be considered fairly representative for the species.

With regard to the absolute minimum vital temperature of potato beetle adults, experiments have shown that this temperature is coincidental with the undercooling point of the individual concerned. If the beetle is cooled until ice formation begins, but is warmed again before the freezing process has proceeded much further, it will recover. However, under natural conditions, when the soil reaches such a temperature that ice formation is started, it will in all probability remain at that temperature, or close to it, long enough for the temperature of the insect to come into equilibrium with it. This equilibrium is reached within two to three hours, and proves sufficient to cause the death of the beetle. Therefore if a temperature low enough to start freezing in the insect body is maintained for this short period of time, death results.

The great range of undercooling points found for *Leptinotarsa decemlineata* adults makes it impossible to set a fixed lethal temperature for these insects, but it seems reasonable to conclude that the mortality will vary from 0% at —4° to 100% at —12°C., with a maximum rate of killing at about —7°C.

Depth of Hibernation.—The depth at which the adult beetles hibernate is largely dependent upon the nature of the soil. Observations by various workers show that the beetles cannot penetrate the hardpan and in some districts do not go below the plow line. In loose, sandy soil Gibson (1925) reports them as hibernating at a depth of 14 to 17 inches, and Tower (1906) makes the general statement that the beetle hibernates at a depth of from 18 inches to 2 feet. At this Station we have found beetles in the experimental cages to go down more than four feet in loose sand. For the purpose of discussion one may then conservatively assume a hibernation depth of 12 to 14 inches. The

question then arises as to the chances of survival under winter conditions in the north which hibernating potato beetles will have. The following data on winter soil temperatures throws some light on this question.

AIR AND SOIL TEMPERATURES.—Recent studies at this station have amply demonstrated the protective nature of a snow blanket. Mail (1930) has shown that even as little covering as four inches of snow is an excellent insulation against lethal cold temperatures to soil inhabiting organisms. The soil itself is by no means such a good insulator but with a snow blanket the surface temperature does not usually drop much below freezing even with very severe cold weather. The following figures picked at random from the records demonstrate the point:

Date	Air temp.	Depth of snow	Soil surface temp.	Temp. at 14"
Feb. 15/32....	—12.3°C.	8"	—3.8	—0.2
Mar. 5/32 ...	—11.3	4	—1.9	0
Mar. 8/32	—26.2	6	—1.8	+0.1
Mar. 10/32....	—26.1	5	—3.4	0
Dec. 7/32....	—29.8	4	—1.3	+2.1
Dec. 8/32....	—30.3	4	—2.8	+1.2
Dec. 10/32...	—26.5	5	—3.5	+0.7
Jan. 16/33....	—20.3	3	—3.1	—0.2
Jan. 18/33....	—14.9	4	—2.9	—0.1
Feb. 8/33.....	—24.3	4	—6.2	—2.7
Feb. 9/33.....	—28.5	4	—7.9	—3.5

As stated earlier in this paper, it is highly improbable that there will occur any mortality in normally hardened beetles at —4°C., but —7°C.

	Feb. 8th °C	Feb. 9th °C
Air temp. 6 inches	—24.3	—28.5
5 "	—21.8	—26.3
Snow level 4 inches	—18.0	—22.8
3 "	—14.9	—19.3
2 "	—11.9	—14.9
1 "	— 7.2	— 9.1
Soil surface	— 6.2	— 7.9
1 inch	— 5.6	— 7.2
2 "	— 5.3	— 7.0
3 "	— 5.1	— 6.8
4 "	— 4.9	— 6.5
5 "	— 4.6	— 6.2
6 "	— 4.4	— 6.0
8 "	— 3.9	— 5.2
10 "	— 3.2	— 4.6
12 "	— 3.0	— 3.8
14 "	— 2.7	— 3.5
16 "	— 2.3	— 2.9
18 "	— 1.9	— 2.5
20 "	— 1.5	— 2.2
22 "	— 1.2	— 2.0
24 "	— 0.9	— 1.6
3 feet	+ 0.9	+ 0.4
4 "	+ 2.2	+ 1.7
5 "	+ 3.2	+ 3.1
6 "	+ 4.4	+ 4.2

will probably eliminate large numbers by death. In the preceding table which represents the minimum temperatures observed during two days of unusually severe weather at Bozeman, there might be expected a high mortality in beetles which were trapped in the first 10 inches, but it is unlikely that those at lower depths would suffer.

Furthermore, compacted soil, such as these records were obtained in, is not a particularly good insulator. But ground used for the growing of potatoes is constantly cultivated to depths of from 6 to 9 inches and this loose surface soil may further increase the insulating effect of the winter snows.

The soil temperature picture in the absence of a snow covering is quite different and cold weather with the ground bare may involve great losses in the hibernating beetles. Four days' records of soil temperature during a cold spell from 29th December, 1927 to 4th January, 1928, at Minnesota, with the ground bare, are here given.

	Dec. 29	Dec. 31	Jan. 1	Jan. 4
Air temp. °C.	—8.5	—19.5	—19.8	—10.0
2″	—4.3	—16.1	—17.9	—10.5
4″	—3.9	—15.5	—17.8	—10.9
6″	—3.1	—14.0	—16.3	—12.3
8″	—2.7	—12.5	—15.2	—12.0
10″	—2.3	—10.75	—13.5	—11.2
12″	—2.1	— 9.4	—12.3	—11.0
14″	—1.8	— 8.2	—11.1	—10.6
16″	—1.7	— 6.9	— 9.7	— 9.7
18″	—1.6	— 5.7	— 8.7	— 9.2
20″	—1.5	— 4.8	— 7.4	— 8.4
22″	—1.4	— 4.2	— 6.6	— 7.5
24″	—1.3	— 3.6	— 5.4	— 6.9

Under such conditions it is doubtful whether hibernating beetles within the first two feet would survive, and even the occasional occurrence of conditions similar to that pictured might prove an effective check on the northward movement of the potato beetle. There always remains the question as to the validity of laboratory determinations of winter hardening and just how closely the data arrived at experimentally agree with the normal conditions.

Soil Temperature Data from Beaver Lodge, Alberta.—Thanks to the courtesy of Mr. W. D. Albright, Superintendent of the Dominion Experimental Substation, at Beaverlodge, Alberta, (Fig. 94) some temperature data have been obtained for the winter months during 1928, 1929, and 1930. In 1928 there were 32 days when the minimum air temperature was 15° below zero centigrade, or lower, with a minimum temperature for that year of —40.5°C. In 1929 the days during which the temperature recorded —15 or lower numbered 65 with a minimum of

—42.2°G. In 1930 there were 46 days below —15°C. and a minimum of —36.7°C.

Soil temperatures at Beaverlodge station are taken by means of a soil thermograph, the bulb being placed three inches under the surface of

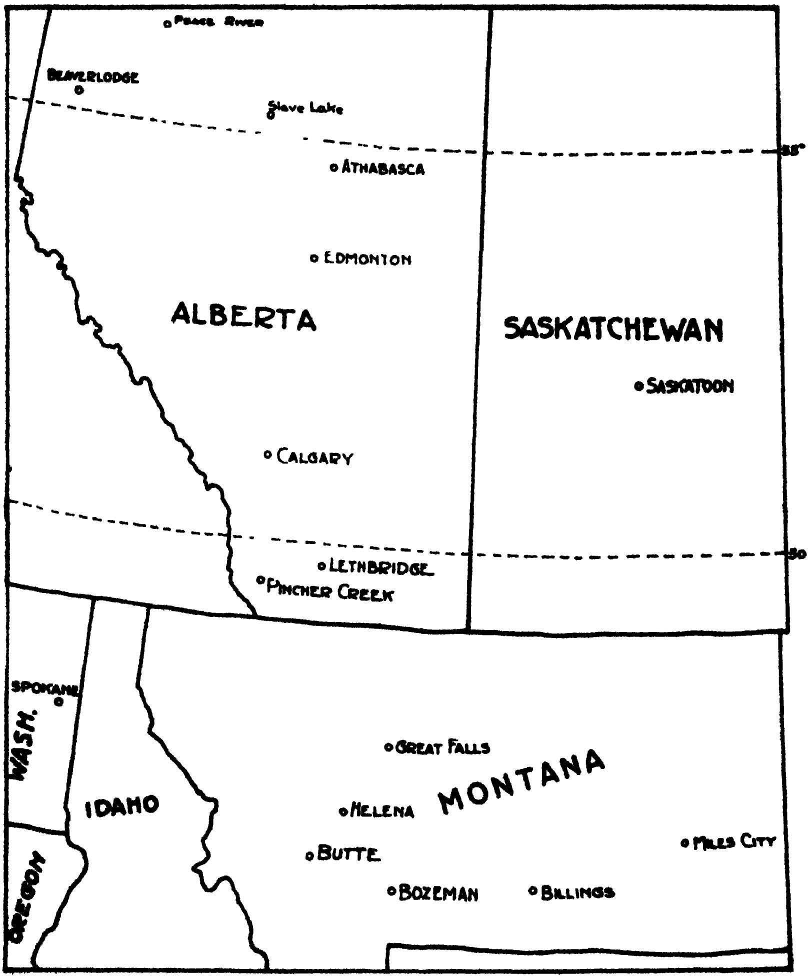

Fig. 94.—Outline map of Montana, Idaho, Alberta and Saskatchewan

bare fallow land. Whilst the records give no information on the depth of the snow covering, the annual reports of the station time and again comment on the effect on soil temperatures of the snow present.

From an examination of the temperatures tabulated below and a

comparison of similar temperatures at the Montana and Minnesota Stations, it is possible to interpolate and postulate what temperatures hibernating beetles at Beaverlodge might have to endure.

BEAVER LODGE DATA—Nov.–March, 1928–29–30

Minimum air temperature °C. Minimum soil temperature 3″ °C.

1928

Air	Soil
—40.5	— 8.9
—33.9	— 8.9
—27.8	— 8.3
—16.7	— 7.8
—15.0	— 3.3
—16.11	— 5.0
—17.8	— 6.1
—17.2	— 6.1
—17.8	— 5.6
—16.1	— 6.1
—17.2	— 7.2
—16.1	— 7.2
—17.22	— 7.2
—15.5	— 7.8
—26.1	— 8.05
—24.4	—10.0
—17.22	—10.0
—16.1	—10.6
—23.3	— 8.9
—23.3	— 8.3
—23.9	— 8.9
—17.2	— 8.3
—17.2	— 7.8
—16.11	— 6.7
—26.11	— 6.7
—31.11	— 6.1
—24.4	— 6.1
—17.2	— 6.8
—18.3	— 6.1
—18.3	— 5.0
—20.6	—
—15.0	— 7.2

1929

Air	Soil
—20.6	— 7.8
—18.3	— 8.3
—20.0	—11.1
—24.4	— 8.9
—21.7	— 9.4
—17.7	— 7.2
—23.3	— 8.3
—22.8	—10.0
—22.2	—10.6
—18.3	—10.0
—21.7	— 8.9
—17.2	—10.0
—27.8	—10.0
—28.3	— 8.9
—27.2	— 8.3

1929 Con't.

Air	Soil
—27.8	— 8.3
—31.11	— 8.3
—36.1	— 8.3
—33.3	— 7.8
—42.2	— 7.2
—32.8	— 7.2
—32.8	— 7.2
—33.3	— 6.7
—26.7	— 7.2
—35.0	— 6.7
—32.8	— 7.2
—25.0	— 7.2
—24.4	6.7
—23.9	- 6.7
—17.8	— 6.7
—16.1	— 6.7
—20.0	— 4.4
—23.9	— 5.6
—28.3	— 6.1
—17.8	— 6.1
—18.9	— 5.0
—21.1	— 5.0
—21.1	— 5.0
—18.9	— 5.6
—18.9	— 5.0
—16.1	— 4.4
—23.9	— 5.6
—26.11	— 4.4
—17.2	— 5.0
—18.9	— 3.9
—21.1	— 4.4
—15.5	— 2.8
—19.4	— 3.3
—17.2	— 5.0
—20.6	— 5.6
—28.3	— 8.3
—28.3	— 8.9
—31.7	— 9.4
—32.8	— 9.4
—29.4	—10.0
—28.3	—10.6
—25.0	— 9.4
—21.1	— 6.7
—26.1	— 7.8
—30.0	— 7.8
—27.2	— 8.3
—22.2	— 8.3
—21.7	— 8.3
—22.8	— 6.1
—15.5	— 6.1

1930

Air	Soil
—22.2	— 8.3
—28.3	— 8.9
—31.1	— 9.4
—36.7	—10.0
—19 4	— 8.9
—21.7	— 9.4
—26.1	— 9.4
—17.2	- 8.3
—21.1	— 8.3
—22.8	— 8.3
—17.8	— 7.8
—28.9	- 8.3
— 18.9	— 7.8
— 23.9	— 8.3
—32.7	—10.0
—38.9	-11.1
—20.00	—10.0
—22.2	— 8.9
— 25.5	—10.0
—22.2	—10.0
— 17.2	—10.0
—18.3	— 8.3
—23.3	— 6.7
—30.0	— 6.9
—30.0	— 7.7
—24.4	- 8.9
—16.1	— 6.1
— 19.4	— 6.1
—16.6	— 6.1
—16.6	— 7.2
—15.5	— 7.2
—18.9	— 7.8
—23.3	— 8.9
—18.9	— 8.3
—16.6	— 7.2
—19.4	— 8.3
—25.0	— 9.4
—28.9	— 7.8
—17.2	— 1.1
—20.0	— 1.7
—15.0	— 2.2
—16.6	— 1.7
—16.6	— 2.2
—16.1	— 1.7
—18.9	— 1.7
—16.6	— 1.1

It will be observed that the minimum soil temperatures at three inches during each of these three years studied were —10.6, —11.1 and —11.1 respectively. Inasmuch as the spread in soil temperatures in the surface two feet is never large in winter, we may safely assume that with a temperature of minus 10 degrees at three inches, the temperature at two feet would not be much if any higher than minus 7 degrees. As previously stated, laboratory studies have shown that a maximum killing rate might be expected at minus 7°C. Granting that this is correct, during each of the three winters at Beaverlodge for which data are given, there would have been an enormously high percentage of mortality amongst potato beetles hibernating in the first two feet. The fact remains that the potato beetle is not present at Beaverlodge and its food plants are there in abundance, and it would appear reasonable to postulate that these winter soil temperatures are the limiting factor. However, until more definite information is obtained about hibernation depths, one cannot make a positive statement on the matter.

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The Chinese mantid, *Paratenodera sinensis* Sauss., has been established in America for a number of years, and in 1930 egg masses were brought to Stamford, Conn., and presumably about that time they were also distributed to certain localities on western Long Island. The year following the insects were found in some numbers. They were somewhat more numerous in the summer of 1932, a number of adults being taken within the City of Stamford, and the past season, 1933, they were decidedly more abundant, and the same appears to be true of localities on western Long Island. The past two or three winters have been somewhat mild, and there is a possibility that the coming, presumably somewhat cold winter, 1933-34, will test the ability of this insect to survive under southern New England and Long Island conditions.

E. P. Felt

THE IDENTITY OF TWO *LYGUS* PESTS (*HEMIPTERA, MIRIDAE*)[1]

By W. EARL SHULL, *Department of Entomology, University of Idaho, Moscow, Idaho*[2]

ABSTRACT

The scientific and common names of the insects *Lygus elisus* Van Duzee and *Lygus hesperus* Knight have been confused. The insects are now known to be distinct species and are therefore raised from the rank of variety to that of species. Differences between the two insects are given and new common names are proposed.

There appears to be some confusion as to the scientific and common names which should be applied to certain of our western *Lygus*, which in the past few years have become important pests on crops such as beans, alfalfa, apples, pears, bramble fruits, and cotton. The two *Lygus* which have been most commonly misnamed are *Lygus elisus* and *Lugus hesperus*. These insects have been called the "tarnished plant bug," the "tarnished bug," and "cotton daubers," and have been discussed in the literature as *Lygus elisus*, *Lygus pratensis*, *Lygus pratensis oblineatus*, *Lygus elisus* var. *hesperus*, and *Lygus pratensis* var. *hesperus* *Lygus elisus* was first described by Van Duzee (1914). Dr. Harry H. Knight discussed this insect as *Lygus elisus* Van Duzee (1917). He described *Lygus hesperus* as *Lygus elisus* var. *hesperus* (1917). This worker recently has been determining *Lygus elisus* as *Lygus pratensis elisus* Van Duzee and *Lygus hesperus* as *Lygus pratensis hesperus* Knight

During recent investigations of the insect pests of beans, the writer has had occasion to study the life history and habits of the two insects, *Lygus elisus* and *Lygus hesperus* Certain differences have been found which indicate that the two insects are distinct species. Apparently they have the same life history (Shull, 1933), but they have a slight difference in host plants. Both are found breeding in large numbers on legumes, especially clover and alfalfa, as well as many wild host plants. *Lygus elisus* only was observed to feed and breed on the red-rooted pigweed, *Amaranthus retroflexus* Many nymphs were collected and reared from this plant and in all cases the adults were *Lygus elisus*. A complete survey of the host plants of the two species has not been made, but a study of the data already obtained indicates a possible variation in the host plant range. The two species were found not to interbreed. Attempted matings of males and females of different species failed to produce eggs, while matings of males and females of the same species

[1]Technical Paper No. 93 of the Idaho Agricultural Experiment Station.

[2]The author wishes to express thanks to Dr. H. H. Knight of Iowa State College for his assistance in this study.

produced many fertile eggs, the nymphs from which were reared to adults, and in all instances, they carried the same specific characters as the parent insects. It was observed that the rostra of some of the insects were longer than those of others, which led to a comparative study of rostra of the two insects. A total of 1,789 rostra of males and females was measured (Table 1).

TABLE 1. ROSTRA LENGTHS OF *Lygus hesperus* AND OF *Lygus elisus*

	Lygus hesperus				*Lygus elisus*			
Length of	Male		Female		Male		Female	
Rostra mm.	No.	% total	No.	% total	No.	% total	No.	% total
1.9......					13	4.15		
2.0					33	10.61	19	5.20
2.1					242	77.85	202	56.44
2.2......					23	7.39	137	38.76
2.3								
2.4......								
2.5	328	51.89	109	22.44				
2.6.. ...	191	30.23	106	21.20				
2.7	92	14.40	206	42.54				
2.8	21	3.48	40	8.29				
2.9			27	5.53				
Total	632	100	488	100	311	100	358	100

These data show that the length of the rostra of *Lygus elisus* varies between 1.9 mm. and 2.2 mm., and that of *Lygus hesperus* between 2.5 mm. and 2.9 mm., or a difference of 0.3 mm. This difference is small, but constant, and is a very useful character in the identification of the two species. The rostra of *Lygus elisus* never reaches past the hind margin of the metathoracic coxae, while that of *Lygus hesperus* always reaches beyond the hind margin of the metothoracic coxae. The males may further be separated by the color of the venter. The venter of *Lygus elisus* is always green in living specimens. The venter of *Lygus hesperus* is always dark brown to black, or with only yellow bars on each segment. The abdomen of the females is always green in both species (live insects). The green of *Lygus elisus* is a bluish-green, while that of *Lygus hesperus* is yellowish-green both in nymphs and adults. The differences in color pattern of the dorsum also is very valuable in separation of the species. The antennal segments of the males of *Lygus hesperus* are longer than the corresponding antennal segments of *Lygus elisus*, except Segments IV which are equal in length. The over-all length of the antennae of *Lygus hesperus* is therefore greater than that of *Lygus elisus*.

Because of the constant morphological differences in length of the rostra and antennal segments, the slight differences in feeding and

breeding hosts, and because the insects apparently do not interbreed, it is believed by the writer that the two insects, which have recently been considered as varieties of the species *Lygus pratensis*, should be elevated to the rank of species. Such an elevation would give the species described by Van Duzee the name *Lygus elisus*, and that described by Knight the name *Lygus hesperus*.

Many species of the genus *Lygus*, especially of the sub-genus *Lygus*, have been called the "tarnished plant bug" This is not surprising, however, since the species are so closely related and the differences in morphological characters are so small, but the fact that so many of them have been called by the same common name is rather confusing. At the present time, *Lygus pratensis oblineatus* (Say) is recognized as the "tarnished plant bug" *Lygus hesperus* Knight and *Lygus pratensis oblineatus* (Say) have been called by Morrill (1918) the "cotton daubers." *Lygus elisus* Van Duzee was called the "tarnished bug" by McGregor (1927). Each of these species is known to many entomologists and laymen, however, as the "tarnished plant bug," therefore, because of such confusion and the increasing importance of these pests they should have distinct common names

Both of the species *Lygus elisus* and *Lygus hesperus* are known to breed throughout their range on alfalfa and clover. This fact was mentioned by Morrill (1918) in Arizona, McGregor (1927) in Arizona and California, and by Webster and Spuler (1931) in Washington *Lygus elisus* was mentioned by Shull and Wakeland (1931) and by Shull (1933) as the cause of "punctured" beans in Idaho These papers emphasize the importance of the two species on legumes. Papers discussing their injury to crops other than legumes state that the insects migrate from the legumes to the crop injured. It is quite apparent, therefore, that the two species are closely associated with legumes throughout their range. Because of this association and the apparent confusion as to the common name which should be applied to these two insects, the writer wishes to propose new common names; for *Lygus hesperus* Knight, the "legume bug," and for *Lygus elisus* Van Duzee, the "pale legume bug."

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INSECTS COLLECTED IN FLIGHT TRAPS IN THE VICINITY OF MOSCOW, IDAHO

By PAUL L. RICE,[1] *Assistant Entomologist, Idaho Agricultural Experiment Station*

ABSTRACT

Flight traps were operated in different types of localities near Moscow, Idaho. The insects caught during two years were determined by specialists. Data on the occurrence and flight habits of approximately 500 species were obtained, of which two-fifths were Coleoptera and one-fifth Hymenoptera.

Insect flight traps were operated near Moscow, Idaho, during the warmer months of 1930 and 1931. The primary purpose of conducting the trap study was to obtain information on the flight habits of the pea weevil, *Bruchus pisorum* (L.), a destructive pest of the region surrounding Moscow. It was soon found, however, that so many insects other than the pea weevil were captured that a valuable contribution to the knowledge of the insect fauna of the vicinity could be made by retaining and studying all of them. This study was undertaken by the writer. It presents in brief form the results obtained.

DESCRIPTION OF THE TRAP.—The trap used in this study was designed by Professor Claude Wakeland and is described in an unpublished paper by him. One of the traps is shown in position in Plate 54. It is sufficient to say here that the trap consisted essentially of a vertical screen panel, at the bottom of which on each side was attached a funnel leading through a small hole into a tin can in such a way that most insects striking the screen and falling through the funnel would be trapped in the can. Some of the insects more active in flight would recover their equilibrium in time to avoid the trap. It was possible to trap insects flying from two sides only. No attractants of any kind were used,

[1]The author wishes to gratefully acknowledge the assistance given him by Professor Claude Wakeland and Dr. W. E. Shull in planning and carrying out the work of this project. He also wishes to acknowledge his deep indebtedness to the 39 specialists who aided him by making determinations.

consequently only those insects that came into contact with the trap during their flights were captured.

LOCATIONS OF TRAPS.—Eight traps were operated during the two years covered in this study. Data on their locations are given in Table 1.

TABLE 1

Trap No.	Location of trap	Directions faced	Distance above ground of bottom of trap
	1930 Locations		
1	Within city limits on University water tank......	NE and SW	65 feet
2	Top of Paradise ridge, 5 miles southeast of Moscow, in woods..........	N and S	20 feet
3	Top of uncultivated knoll 2 miles south of Moscow	E and W	4 feet
4	Top of ridge in wheat field 2 miles south of base of Moscow Mt..............................	NE and SW	3 feet
5	Top of high uncultivated knoll next to timber at base of Moscow Mt., 8 miles northeast of Moscow..........	NE and SW	4 feet
6	Top of Moscow Mt. ridge in woods, 10 miles northeast of Moscow	N and S	15 feet
7	Low ground in pea field 3 miles west of Moscow .	E and W	6 inches
8	Side hill in wheat field 3¼ miles west of Moscow..	N and S	6 inches
	1931 Locations		
1	Knoll in wheat field 2½ miles southwest of base of Moscow Mt..............	NE and SW	4 feet
2	Same as in 1930..................	N and S	20 feet
3	Same as in 1930	E and W	4 feet
4	Knoll in pea field 3½ miles southwest of base of Moscow Mt....................	NE and SW	4 feet
5	Same as in 1930..................	NE and SW	4 feet
6	Same as in 1930..................	N and S	25 feet
7	Same as in 1930; field planted to wheat..........	E and W	4 feet
8	Same as in 1930; field planted to peas..........	E and W	4 feet

It will be seen that the locations ranged from the top of Moscow Mountain Ridge, 10 miles northeast of Moscow, to a position in cultivated fields three and one-fourth miles west of the city. The traps were suspended from 6 inches to 65 feet above the ground. The approximate elevations of those trap locations that were notably higher than the elevation at Moscow were as follows: Trap No. 2— 3300 feet; Trap No. 3—2950 feet; Trap No. 5—3175 feet; Trap No. 6—4050 feet. The other traps were in locations where the altitude varied from 2650 feet to 2750 feet.

COLLECTIONS FROM TRAPS.—The first collections were made from the traps during the first part of May in both 1930 and 1931. They were discontinued on October 11 in the former year and on November 6 in the latter. Traps Nos. 3, 7 and 8 were not operated after August 1 in 1931. The traps were usually visited at weekly intervals, but sometimes weather conditions or other factors necessitated a deviation from the

Plate 54

Insect flight trap in position in wooden region

schedule. All the trapped insects remaining alive when collections were made were killed in cyanide jars. The collections from the different sides of each trap were kept separate, stored, and at a later date all but large series of duplicates and the badly broken specimens were mounted. They were then separated into the larger groups and sent to specialists for determination. All mounted specimens were identified with the exception of about half of the Diptera and the Trichoptera. There appeared to be but one species of the latter order in the collections.

RESULTS.—Nearly 12,000 insect specimens were obtained during the two years. Four hundred ninety-seven species were represented. This number would have been considerably larger had it been possible to identify all specimens obtained. The 497 species were distributed among 12 orders and 108 families, as shown in Table 2. It will be seen here that the orders Coleoptera and Hymenoptera were represented by the largest number of species; over two-fifths of the species captured were Coleoptera and over one-fifth were Hymenoptera.

TABLE 2. NUMBER OF FAMILIES AND SPECIES REPRESENTED UNDER EACH ORDER COLLECTED

Name of order	Number of families	Number of species	Name of order	Number of families	Number of species
Orthoptera	3	8	Hemiptera	14	56
Isoptera	1	1	Coleoptera	39	211
Neuroptera	3	4	Trichoptera	1	1
Ephemerida	1	5	Lepidoptera	7	32
Corrodentia	1	1	Diptera	11	30
Homoptera	6	33	Hymenoptera	21	115
Total				108	497

A comparatively small number of the species appeared in both 1930 and 1931, for only 134 species, 27 per cent of the total, were collected both years. The total number of species collected in 1930 was 372, while in 1931 it was but 259. Two hundred thirty-eight species which did not appear at all in 1931 were collected in 1930, while 125 species were collected only in 1931. Although a large majority of those species which appeared one year only were represented by but one specimen, as high as 55 specimens of a species were collected one year, while not a single representative of that species was obtained the other year. Even when a species appeared both years, there was often a large variation in the number of specimens captured each year. For example, 189 specimens of a leafhopper, *Euscelis* sp., were collected in 1930, while in 1931 the number had increased to 1207, an increase of nearly 700 per cent.

The specimens collected of an individual species ranged in number from one to 3,387. Only one specimen each of 261 species was collected.

Those species having more than 100 representatives in the collections were as follows: *Bruchus pisorum* (L.), the pea weevil, 3,387 specimens; *Aphodius distinctus* (Mull.), a small dung beetle, 2,653 specimens; *Euscelis* sp., a leafhopper, 1,396 specimens; *Mycterus concolor* Lec., a melandryid beetle, 226 specimens; and *Bibio xanthopus* var. *palliatus* McAtee, a marchfly, 117 specimens.

Some species of insects showed a very limited distribution over the area covered by the traps while others were widely distributed. Many species were found only in traps in wooded regions, while others were found only in the cultivated areas. The outstanding example of an insect distributed widely over the area was the dung beetle, *Aphodius distinctus* (Mull.), which was collected both years in all eight traps. The finding of some insects in traps remote from their normal breeding areas gives evidence of flights of considerable distances The bark beetle, *Scolytus ventralis* Lec., the host of which is the lowland white fir, was collected in greater abundance in traps remote from wooded districts than in the traps situated in or near these areas One such specimen was collected in a trap at a distance of six miles from a white fir stand, showing that the species must travel long distances in search of suitable host trees.

The number of species collected each week was greatest in the spring. The maximum number of species was obtained the week ending May 17 in 1930, while in 1931 the year's maximum was reached the week ending May 30. There was a decrease in the number of species obtained per week until the low point of the year was reached the latter part of August and the first part of September. Then there was an increase in numbers until the cold weather set in.

The collection of *Mysia randalli* Csy., a coccinellid beetle, in the traps at Moscow, contributed to the knowledge of its range. Dr. Th. Dobzhansky, who identified the Coccinellidae, in commenting on the occurrence of this insect in Idaho, says: ". . . This is a species known so far only from the region between Lake Superior and Labrador. Its occurrence in Idaho is rather unexpected . . . "

The locations of the traps had no consistent effect on the number of species captured; neither did the direction faced by the traps consistently influence the number of specimens collected. As a rule, more species were captured in traps on high ground than in those on low ground. The number of species captured in the trap suspended 65 feet above the ground was greater than in some traps placed near the ground, but less than in other lowly suspended traps. There was no consistent difference in the number of species caught in cultivated and wooded

areas. Since the prevailing wind in the Moscow vicinity is from the southwest it would seem logical to suppose that more insects would be collected on the south, southwest and west sides of the traps than on the opposing sides. This proved to be true in 1930. However, the reverse proved to be the case in 1931, because in every trap a larger number of insects was captured in the side facing away from the source of the prevailing wind. Since southwest winds seemed to be more prevalent in 1931 than in 1930, the prevailing wind did not seem to influence the catch on the different sides of the traps.

A METHOD FOR TEMPORARY INHIBITION OF COAGULATION IN THE BLOOD OF INSECTS[1]

By W. EARL SHULL and PAUL L. RICE, *Department of Entomology, University of Idaho, Moscow, Idaho*

ABSTRACT

Any desired degree of inhibition of coagulation in the blood of the cockroach may be obtained by treating the roaches (*Blatella germanica* and *Periplaneta orientalis*) with acetic acid vapors when the time of exposure and temperature are controlled. The apparatus and technique employed in subjecting the cockroaches to acetic acid vapor together with some data obtained by the use of this method are presented.

In a study of the effect of certain toxic gases upon the coagulation of the blood of the cockroach Shull, Riley and Richardson (1932), observed that, in those insects which were exposed to the vapors of glacial acetic acid, coagulation of the blood was temporarily inhibited and that the blood cells appeared normal as in uncoagulated blood. Normal coagulation of the blood of the cockroach was described by Yeager, Shull and Farrar (1932). This paper is a report of further work with acetic acid vapor in its effect on coagulation of insect blood. The laboratory animals used in this study were the German cockroach, *Blatella germanica*, and the oriental cockroach, *Periplaneta orientalis*.

An insect to be treated was placed in the bottom of a glass tube which was one inch in diameter and eight inches long. The bottom of the tube was perforated by numerous holes. Two corks were attached to a thermometer which was suspended in the tube. The lower cork, which was of the proper size to slip easily within the tube, was attached in an inverted position just above the bulb of the thermometer. The upper cork, which closed the top of the tube, was attached so that when it was in position the lower cork would be one and one-half inches from the

[1]Technical paper No. 99, Idaho Agricultural Experiment Station.

bottom of the tube. Both corks were dipped in paraffin to prevent the absorption of acetic acid vapor. When the corks and thermometer were in place, the insect was confined to the lower one and one-half inches of the tube, and the temperature of that area could be read at all times. This tube and its contents was placed inside another tube which was slightly larger in diameter and one-half inch longer. The larger tube was suspended from a clamp into a constant temperature bath so that the lower six inches of the tube was immersed in the water. The opening between the two tubes was loosely sealed at the top by means of rubber bands wound around the inner tube. The insect was subjected to bath temperatures in this manner for ten minutes or more in most cases. This was thought to be sufficient time for the temperature of the insect's body to reach that of the bath. At the end of this period, the inner tube containing the insect was rapidly transferred to another large tube immersed in the bath This tube was of the same size and shape as the first outer tube but contained in the bottom 2 cc of acetic acid After exposure to acetic acid vapor for the desired length of time, the insect was taken out and a drop of blood was immediately removed by severing an antenna, and dipping the severed end into a drop of nujol oil on a slide glass. The blood was then examined under a compound microscope Treated insects were retained for observation in glass-tube or pill-box cages.

Four pairs of the treating tubes described above were used in the study. Consequently two or three insects could be warmed in the bath while the fourth was being treated. It was found that only slight change in temperature was produced when the tube containing an insect was transferred from the tube in which it had been warming to one containing the acetic acid. The perforated tubes were wiped out after each treatment in order to remove any moisture that had accumulated. New glacial acetic acid was used for each day's treatments.

The procedure and apparatus described in the foregoing paragraphs were those that were finally used. All specimens of *P. orientalis* were treated as described above, however the treatment of specimens of *B. germanica* varied somewhat. The corks used while working with this species were not dipped in paraffin to prevent absorption of acetic acid vapor. As a consequence the odor of acetic acid could easily be detected on these corks. The small amount of vapor released from them possibly affected the insects to a slight degree while being warmed and before they were suspended in the tube containing the acid.

A small number of specimens of two Coleopterous species were subjected to the acid treatment. A few cockroach specimens were sub-

jected to the higher temperatures in the range investigated without treating with acid.

The sex of the insect, the length of time the insect was in the bath before treatment, the length of the period of treatment, and the vapor temperature at the time of treatment were recorded. Note was made as to whether or not coagulation of the blood had occurred within one or two minutes after removal from the insect and whether or not it had occurred 24 hours or more later. Whether the insect was living or dead at these two periods was also recorded The results obtained from treatment of 71 specimens of *Blatella germanica* are given in Table 1, and results obtained from treatment of 104 specimens of *Periplaneta orientalis* in Table 2. The entire series of *P. orientalis* treated were males. The notation "x" in the "Coagulation of blood" column signifies that coagulation had occurred The notation " -" in this column indicates that coagulation had not occurred In the "Insects alive" column an "x" means that the insect was living at the time of observation and a "–" means that it was dead If any movement was exhibited by the insect, it was recorded as living Consequently, when an insect was recorded as living it should not be inferred that it was normal. Where a question mark occurs, the droplet of blood had either dried or some other factor had made it impossible to determine the state of coagulation.

TABLE 1. THE EFFECT OF ACETIC ACID VAPOR ON THE GERMAN COCKROACH, *Blatella germanica*

Insect No.	Treatment in minutes		Temp. at time of acid treatment	Coagulation of blood		Insect alive		Sex
	warming	acid		At removal	24 hrs. after removal	At removal	24 hrs. after removal	
1	10	3.6	20.0°C	x	x	x	x	female
2	10	3.5	21.0	x	x	x	x	female
3	10	3.4	22.0	x	x	x	x	female
4	10	3.3	23.0	x	x	x	x	female
5	10	3.5	23.0	x	x	x	x	female
6	10	3.5	23.0		?	x	x	male
7	10	3.7	23.0			x	x	female
8	10	3.6	24.0	x	x	x	x	male
9	10	3.5	25.0	x	x	x	x	female
10	10	1.0	25.5	x	x	x	x	male
11	10	4.0	25.5			x	x	male
12	10	2.0	26.0	x	x	x	x	male
13	10	2.5	26.0	x	x	x	x	male
14	10	3.0	26.0			x	x	male
15	10	3.0	26.0			x	x	male
16	10	3.4	26.0			x	x	male
17	10	3.5	26.0			x	x	male
18	10	3.6	26.0	–	–	x	x	female
19	10	5.0	26.0	-	?	x	x	female
20	10	3.3	27.0	x	x	x	x	female
21	10	3.2	28.0		x	x	x	male
22	10	2.7	29.0		x	x	x	male
23	10	2.0	30.0	x	x	x	-	male

TABLE 1 *Concluded*

Insect No.	Treatment in minutes warming	Treatment in minutes acid	Temp. at time of acid treatment	Coagulation of blood At removal	Coagulation of blood 24 hrs. after removal	Insect alive At removal	Insect alive 24 hrs. after removal	Sex
24	10	2.6	30.0	x	x	x	x	female
25	10	2.6	30.0	-	-	x	x	male
26	10	2.6	30.0			x	x	male
27	10	2.6	30.0	x	x	x	x	female
28	10	3.5	30.0		-	x		male
29	20	1.0	31.0	x	x	x	x	male
30	5	2.0	31.0	–	x	x	x	female
31	13	2.0	31.0	No blood		x	x	male
32	10	2.25	31.0	x	x	x	x	male
33	10	2.5	31.0	-		x		male
34	10	2.5	31.0	-	x	x		male
35	10	2.9	31.0	x	x	x	x	female
36	5	3.0	31.0	–		x	x	male
37	10	3.0	31.0		-	x		male
38	5	3.5	31.0			x	x	male
39	5	3.5	31.0		x	x	x	female
40	10	2.4	32.0	x	x	x		male
41	10	3.0	32.0			x	x	female
42	10	2.3	33.0			x	x	male
43	10	2.95	33.0			x	x	female
44	10	2.2	34.0	x	x	x	x	male
45	10	2.8	34.0			x	x	female
46	10	2.1	35.0	-		x	x	male
47	10	2.7	35.0			x		female
48	10	1.0	35.5	x	-	x	x*	female
49	14	1.0	36.0	x	x	x	x	male
50	10	1.5	36.0		-	x	*	male
51	14	1.5	36.0	x	x	x	x	male
52	15	1.75	36.0		x	x	x	male
53	10	2.0	36.0			x	x	male
54	10	2.0	36.0			x		male
55	10	2.5	36.0		-	x	*	female
56	10	2.6	36.0			x	x	female
57	10	2.0	36.5		-	x	-*	male
58	10	2.1	37.0			x	x	male
59	10	2.5	37.0	-		x	x	female
60	10	2.0	38.0			x		male
61	10	2.4	38.0			x	x	female
62	10	1.9	39.0			x		male
63	10	2.3	39.0	–	x	x	x	female
64	10	1.8	40.0	-				male
65	10	2.2	40.0			x	x	female
66	10	0.5	40.5	x	x	x	x*	female
67	11	1.0	41.0		-	x	x*	female
68	10	1.5	41.0			x		male
69	10	1.9	41.0			x	x	female
70	10	1.5	41.5	No blood		x	-*	female
71	10	1.5	41.5	-	-	x	-*	male

*Observation was made six days after treatment.

DISCUSSION.—These data show that coagulation of the blood of the German and the oriental cockroaches may be influenced by subjecting the insects to a treatment of acetic acid vapor. Different degrees of inhibition may be produced which vary from a slight slowing up of the

TABLE 2. THE EFFECT OF ACETIC ACID VAPOR ON THE ORIENTAL COCKROACH, *Periplaneta orientalis*

Insect No.	Treatment in minutes warming	Treatment in minutes acid	Temp. at time of acid treatment	Coagulation of blood At removal	Coagulation of blood 24 hrs. after removal	Insect alive At removal	Insect alive 24 hrs. after removal
1	15	4.5	24.8°C.	x	x	x	x
2	15	6.0	25.0	x	x	x	x
3	15	6.5	25.0	x	x	x	x
4	15	7.0	25.0	–	–	x	x
5	15	7.5	25.0	x	x	x	x
6	15	8.0	25.0	–	–	x	x
7	15	8.5	25.0	–	–	x	x
8	15	9.0	25.0	–	–	x	x
9	15	9.0	25.0	x	x	x	x
10	15	9.5	25.0	–	–	x	x
11	15	10.0	25.0	–	–	x	x
12	15	10.5	25.0	–	–	x	x
13	15	11.0	25.0	–	–	x	x
14	15	11.5	25 0	–	–	x	x
15	15	12 0	25.0	–	–	x	–
16	15	12.0	25.0	x	x	x	x
17	15	12.5	25.0		–	x	x
18	15	12.5	25.0	–	?	x	x
19	15	13.0	25.0	–	–	x	x
20	15	13.0	25 0	–	–	x	x
21	15	13 6	25.0		–	x	–
22	15	14.0	25 0	–	–	x	x
23	15	15 0	25.0		–	x	x
24	15	15.0	25.0		–	x	x
25	15	17.5	25.0		–	x	–
26	15	19.2	25.0	–	?	x	–
27	15	20 0	25.0		–	x	–
28	15	12.5	26.0	x	x	x	x
29	15	14.5	26.0			x	x
30	15	14.0	27 0		–	x	–
31	15	13.5	28.0	–		x	–
32	15	13.2	29.0			x	x
33	10	2.5	30.0	x	x*	x	x*
34	10	3.0	30.0	x	x*	x	x*
35	10	3.5	30.0		x*	x	x*
36	10	4 0	30.0	–	*	x	–*
37	10	4.5	30.0	x	x*	x	x*
38	10	5.0	30.0	x	x*	x	–*
39	10	5.5	30.0		–*	x	x*
40	10	6.0	30.0		–*	x	x*
41	10	6.5	30.0		?*	x	–*
42	10	6.5	30.0	–	–*	x	x*
43	10	7.0	30.0	–	–*	x	–*
44	10	7.5	30.0		–*	x	x*
45	10	8.0	30.0	x	x*	x	x*
46	15	9.0	30.0	–	–*	x	x*
47	15	10.0	30.0	–	–*	x	x*
48	15	11.0	30.0	–	–*	x	–*
49	15	12.5	30.0	–	–	x	x
50	15	12.0	31.0	–	–	x	–
51	15	11.5	32.0	–	–**	x	–**
52	15	11.0	33.0	–	–**	x	–**

*Observation made 48 hours after treatment.
**Observation made 66 hours after treatment.

TABLE 2. *Concluded*

Insect No.	Treatment in minutes warming	Treatment in minutes acid	Temp. at time of acid treatment	Coagulation of blood At removal	Coagulation of blood 24 hrs. after removal	Insect alive At removal	Insect alive 24 hrs. after removal
53	15	10.5	34.0		-**	x	-**
54	15	1.5	35.0	x	x	x	x
55	15	2.0	35.0	x	x	x	x
56	15	2.5	35.0		-	x	x
57	15	3.0	35.0			x	x
58	15	3.5	35.0			x	x
59	15	4.5	35.0		-	x	x
60	15	5.5	35.0	-		x	x
61	15	6.5	35.0			x	x
62	15	7.5	35.0			x	x
63	15	8.5	35.0			x	x
64	15	9.0	35.0			x	x
65	15	10.0	35.0		**	x	**
66	15	9.5	36.0		**	x	**
67	15	9.0	37.0		-**	x	**
68	15	8.5	38.0		**	x	-**
69	15	8.0	39.0		-**	x	**
70	15	1.0	40.0	x	x	x	x
71	15	1.5	40.0	x	x	x	x
72	15	2.0	40.0			x	x
73	15	2.0	40.0		x	x	x
74	15	2.0	40.0		x	x	x
75	15	2.0	40.0		x	x	x
76	15	2.0	40.0	x	x	x	x
77	15	2.25	40.0	x	x	x	x
78	15	2 5	40.0		-	x	x
79	15	2.5	40.0		x	x	x
80	15	2.5	40.0		x	x	x
81	15	2.75	40.0		x	x	x
82	15	3.0	40 0		x	x	x
83	15	3.25	40.0		-	x	x
84	15	3.25	40.0		x	x	x
85	15	3.5	40.0	x	x	x	x
86	15	3.5	40.0	x	x	x	x
87	15	4.0	40.0		-	x	
88	15	4.0	40.0		-	x	x
89	15	4.0	40.0			x	
90	15	4.5	40.0		-	x	x
91	15	7.5	40.0		-	x	
92	15	7.0	41.0		-	x	
93	15	6.5	42.0			x	
94	15	6.0	43.0		-	x	
95	none	1.0	44.0	x	x	x	x
96	none	1.5	44.0	x	x	x	x
97	none	2.0	44.0			x	x
98	15	5.5	44.0			x	
99	none	5.5	44.5			x	-
100	12	1.5	45.0			-	
101	15	2.0	45.0				-
102	none	3.0	45.0		-	x	x
103	none	4.0	45.0		-	x	-
104	15	5.6	45.0		-	x	-

*Observation made 48 hours after treatment
**Observation made 66 hours after treatment

normal coagulation processes to inhibition which extends over two days or more. It is obvious that the length of exposure and temperature of exposure are factors which influence the degree of inhibition secured. If the tables be analysed, it will be seen that, in general, the time of exposure required to stop coagulation varied inversely as the temperature. There was some individual variation in the time required to inhibit coagulation at any one temperature. This was probably due to differences in physiological conditions of the insects treated. It is quite probable that age variation may have a considerable influence upon the ability of the insect to survive treatment with acetic acid vapor.

It was found that coagulation could be inhibited in the two species of Coleoptera which were treated with acetic acid.

Subjection of insects to temperatures of 40° C. or above has a very marked effect on the coagulation processes. The coagulation of the blood was inhibited for varying lengths of time when roaches were subjected to temperatures of 40° and 45° for fifteen minutes, without acid treatment. However, many of the cells in blood taken from *P. orientalis* specimens subjected to temperatures of 45° were very irregular in shape.

A small number of the insects treated appeared to regain normality after treatment, but a large majority of them, although alive at the end of the treatment and usually alive 24 hours later, were abnormal in appearance, and most of them died within a few days. Some of the specimens treated at the higher temperatures were dead at the end of the treatment and a few were lifeless at the end of the warming period, before treatment with acid However, many of the roaches which had been treated until coagulation was inhibited for a very short time, and a few in which coagulation was stopped for 24 hours, were apparently normal soon after removal, and seemed to be normal up to several days thereafter. This seems to indicate that when an insect is subjected to the right length of exposure to acetic acid vapor, coagulation may be inhibited and yet the insect will return to apparent normality. This method of treatment should prove very useful in the study of many phases of insect physiology and toxicology where it is necessary to study the blood in its normal morphological form.

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WESTERN WILLOW TINGID, *CORYTHUCHA SALICATA* GIBSON, IN OREGON[1]

By B. G. THOMPSON, *Asst. Entomologist, Oregon Agricultural Experiment Station*
and KWAN LUN WONG

ABSTRACT

Notes on life history, distribution on apples in Oregon and control measures are discussed. The overwintering adults were found quite difficult to kill with the sprays tried. The nymphs were killed readily by most of the insecticides used. Pyrethrum extracts, nicotine sulfate 40%, oil emulsions and whale oil soaps were tried alone and in combination.

Tingids, commonly known as lace bugs, are small, flat, oval or oblong insects with reticulated upper surfaces often lace-like in appearance, hence the common name. They are often regarded as an unimportant pest on account of their infestation being mostly on the uncultivated plants and their occurrence in small numbers.

In several Oregon orchards during the last few years, the western willow tingid, *Corythucha salicata* Gib., occurred abundantly on apple and sparingly on willow, which is supposed to be its chief host, even though the latter plant is found in the same orchard. Infestation has increased each year. The following study of a year's work merely serves as a preliminary report and awaits further research on the different phases of the problem.

DISTRIBUTION.—The western willow tingid, *Corythucha salicata* Gib., has been reported from Oregon, Washington, Manitoba and British Columbia In Oregon it has been found doing damage on apple in Lebanon, Salem and Dallas, and has been recorded from Monroe, Portland, Hood River and Corvallis.

ECONOMIC IMPORTANCE.—Adults, as well as nymphs, procure their food by sucking the juice in the leaf tissue The injury resulting to the plant is indicated by the brown and sunburnt appearance of the leaves. The black excrement and moulted skins of the nymphs on the under-surfaces of the leaves give a good identifiction of the presence of the pest. The tissue surrounding the eggs is somewhat hard and corky, and distortion of the ribs may happen where many eggs are deposited on a leaf. An infested orchard can be recognized by a brown unhealthy color instead of a rich green appearance. By the middle of July most of the injured leaves turn brown, dry up and fall, and the orchard resembles

[1]Published as technical paper No. 206 with the approval of the Director of the Oregon Agricultural Experiment Station. A contribution rom the Department of Entomology.

the winter condition. A heavily infested orchard was so damaged by the tingid that practically 100 per cent of the crop was lost.

Description of Stages

Adults. Size of female is 3.55 by 2 mm. Male is a little smaller, being 3.45 by 1.9 mm. Color in general is above white or creamy with a brown band near the apex and a faint brown band across the base of the elytra. A brown spot at the center of the costal margin and the brown tumid elevation of the elytra are usually very prominent. There are comparatively few spines on the membranous margins and nervures. Pronotal hood is slightly higher than median carina and height of hood is about one-half its own length (Fig. 95, 1). Median carina is of normal height. Lateral carinae are long and terminate a short distance from base of hood. Reticulations of globose portion of hood are about the same size as those of paranota. The western willow tingid was first described by Gibson and named *Corythucha salicata* (1*). The type is taken from Hood River, Oregon.

In the same paper Gibson described another tingid as a new species, called *Corythucha drakei*, which is taken from apple tree in Portland, Oregon. He distinguished *salicata* from *drakei* by the less arched median carina, which is slightly shorter, and by, the angulate tumid elevations of the elytra. Drake, 1921 (2) reports that it is impossible to separate *C. drakei* from *C. salicata*, and considers *drakei* as a synonym of *salicata*, according to the law of priority.

Egg (Fig. 95, 3). The eggis small, light brown and semitransparent in basal half; subelliptical in outline and slightly curved. The basal end is rather bluntly pointed and the apical end capped with a narrow cylindrical collar surmounted by a low pyramid with ridges extending from the base to the apex. The pyramidal portion of the apical end is greyish in color. Below the collar the exposed portion of the egg is covered with a black, sticky substance which hardens soon after oviposition. The length of the egg averages .47 mm. with its width .19 mm.

Nymphs (Fig. 95, 4, 5, 6). *First nymphal stage.* General form more cylindrical, elongated and thicker than the other instars. Length varying from .52 to .68 mm.; the greatest width from .23 to .28 mm. At the time of hatching the nymph is pale in color. Fully matured specimens are dirty yellow. Antennae three-segmented; rostrum four segmented and about three-fifths as long as the entire body; legs long and stout. Head bears five tubercles with spines on them. Both pro- and meso-thorax are armed with a spine on each. Meso-thorax also with a dorsal pair of tubercles. Abdomen consists of ten segments; segments two to nine each with a small tubercle bearing a slender spine on each side.

Second nymphal stage. The change which occurs in the first moult is not great. Body is broader. Length varies from .85 to .95 mm.; the greatest width from .41 to .45 mm. Color is darker yellow. Spines are stronger and longer with additional ones on various regions.

Third nymphal stage. Length varies from 1 07 to 1.12 mm.; the greatest width from .50 mm. to .58 mm. Antennae become four-segmented. The legs are slender and shorter in proportion to the length of the body than before.

Fourth nymphal stage. The most noticeable change which takes place in the fourth stage is the first appearance of the wing pads, which arise as curved, backward growths of the sides of the meso-thorax. The wing pads extend back on each

*Literature cited.

side to the middle of the second abdominal segment. The pro-thorax is proportionately longer than before and bears two pairs of dorsal tubercles. The general color is

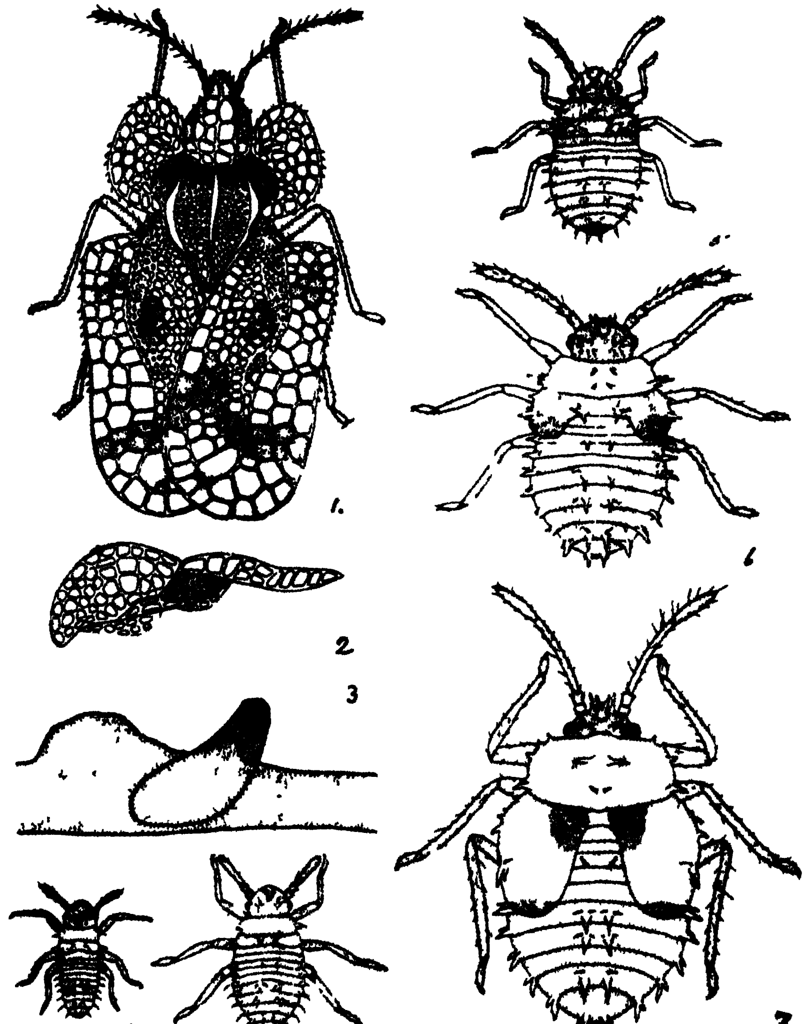

FIG. 95 —Western willow tingid and its various stages

yellow with wing pads embrowned. Length varies from 1.35 to 1.50 mm.; the greatest width from .81 to .87 mm.

Fifth nymphal stage. The most noticeable changes which occur in the fifth stage are the increased length of the prothorax in proportion to the length of the body, and the increase in length of the wing pads. The wing pads now extend back on each side to the middle of the fifth abdominal segment. The pro-thorax is very promi-

nent, the median anterior portion being considerably raised and inflated. The general color is yellow with tips of the wing pads embrowned and with 2 prominent brown spots near the base of the dorsal tubercles on the wing pads. Length varies from 2 to 2.25 mm.; the greatest width from 1.12 to 1.25 mm.

Life History and Habits

Eggs. The eggs are deposited on the under surface of the leaf, usually along both sides of the ribs, especially the midrib. About three-fifths of the egg is inserted into the tissue, leaving the two-fifths protruding from the leaf (Fig. 95, 3). The exposed portion of the egg is covered with a black sticky substance. The eggs are generally placed singly and in no definite order.

The eggs are deposited during the latter part of April until beginning of July. They are quite large in proportion to the size of the abdomen. The ovary can contain only a few fully formed ova at one time. This probably accounts for the long period of egg deposition. The number of eggs found in a single leaf varies from 50 to 528 in a leaf 6 cm. long and 3.5 cm. in diameter. Judging by the first field observation of eggs and the first field observation of newly hatched nymphs, it takes about three weeks for the incubation period.

Nymphs. The gregarious habit of the nymphs is more pronounced in the first two instars. They gradually scatter during the older stages. Newly hatched nymphs are not so active and are found moving not far away from the empty egg cases. Moulting skins of the first instar nymphs are found on the leaves where eggs are laid. Nymphs of all instars feed on the underside of the leaves where they suck the sap of the tissue and cause the leaves to dry. Discoloration caused by their feeding is very conspicuous on both sides of the leaves. In addition to this discolored area, there are small black spots on the underside of the leaves where the excrement has been deposited.

The nymphal stages are represented by five instars. All stages are found in the field from middle of June to the end of July. The length of the different instars is as follows:

1st instar	3 to 6 days
2nd instar	3 to 5 days
3rd instar	3 to 5 days
4th instar	5 to 9 days
5th instar	4 to 8 days

Adults. Adults, like the nymphs, feed on the underside of the leaves and injure them in the same manner. They are also gregarious in habit. Hundreds of them may be found clustering in a single leaf. They are not actively flying insects, being spread gradually in the orchard.

The winter is passed in the adult stage and hibernation begins early in September. Wilson and Lovett (3) report that hibernation takes place in the rubbish on the ground. Under field observation it is found that most adults hibernated among the moss on standing trees in or near the orchard, and sparingly in rubbish on the ground or under bark of trees. There were 711 hibernating adults found in one liter of moss from standing trees near the orchards In all cases where tingids have done damage to apples in the Willamette Valley, there were adjacent to the orchards, woods, usually of oak, heavily covered with moss and invariably infestation started on the trees next to the woods

The overwintering adults come out on warm days in the spring. In Lebanon, where the most serious infestation has occurred, it was found averaging 10 insects per bud after they left their hibernating quarters. In one severe case 112 tingids were found in a single bud The adults first appear on the trees near the hibernation quarters and keep on spreading in the orchard Feeding and mating were observed soon after emergence. Eggs were laid about three weeks later and brood rearing of the season started

SEASONAL HISTORY —There is apparently only one generation a year. Overwintering adults come out in early April Egg deposition covered rather a long period, starting late in April and continuing to the beginning of July. Eggs began to hatch the latter part of May and took from 19 to 29 days for the development of the five instars. The first generation adults were observed about the middle of June up to the beginning of August Early in September they begin to hibernate and come out the next spring.

CONTROL —Preliminary spray tests were applied at the Davidson orchards in Linn county. About 12 acres of these orchards were infested. So severe was the infestation that the infested trees had dropped all their leaves by July 1. The tests were applied with a wheel barrow type sprayer. Two trees were used in each test. The trees were thoroughly drenched with the spray solution. The sprays were applied on April 27.

The following sprays were applied:

No. 1.—Ammonium caseinate oil emulsion (Oil No. 6) 3%.
No. 2—Same plus Black Leaf 40, 1 to 800.
No. 3—Same plus Black Leaf 40, 1 to 600.
No. 4—Black Leaf 40, 1 to 600.
No. 5—Pyrocide 40, 1 to 800.
No. 6—Pyrocide 40, 1 to 400.
No. 7—Pyrocide 40, 1 to 400, plus oil emulsion (as used in No. 1) 3%.
No. 8—Whale oil soap 4 pounds to 50 gallons.

Tingids that were thoroughly wet with the spray were caged for observation. On most of the plots the tingids showed but little effect from the sprays. On plots 1, 7 and 8, about 50% of those wet with the spray were killed.

The tests were repeated against the nymphs of June 27, and almost 100 per cent kill was obtained with all the sprays used.

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SOME TESTS WITH FLUORINE COMPOUNDS AGAINST THE PEPPER WEEVIL, *ANTHONOMUS EUGENII* CANO[1]

By J. C. ELMORE,[2] *Bureau of Entomology, United States Department of Agriculture*[3]

ABSTRACT

Several fluorine compounds have been tested with respect to their insecticidal value against the pepper weevil as compared with that of calcium arsenate. Sodium fluoaluminate (synthetic cryolite), potassium fluoaluminate, and barium fluosilicate gave a higher weevil mortality than did calcium arsenate but, except in the case of potassium fluoaluminate, injury to the plants overshadowed weevil control. The injury was less pronounced in the absence of moisture or when silicon dioxide was added to the fluorine compound. Because of plant injury following treatments with fluorine compounds and the residue problem, these materials are not to be recommended as a control for the pepper weevil.

In connection with investigations of the control of the pepper weevil, a number of fluorine compounds have been tested both as to weevil mortality and as to plant injury in comparison with the effects produced by calcium arsenate and the results are presented herein simply to show the

[1]Order Coleoptera, family Curculionidae.

[2]Acknowledgments for assistance are due to S. F. Bailey and G. E. Washburn, who were detailed by the University of California to assist in the pepper weevil investigations. P. C. Ting also gave valuable assistance during the 1931 season. The author also acknowledges his indebtedness to R. E. Campbell for advice and criticisms during the progress of these investigations.

[3]All these materials except barium fluosilicate, calcium fluosilicate, and calcium arsenate were furnished by the United States Bureau of Chemistry and Soils through R. H. Carter.

comparative effect of calcium arsenate and several fluorine compounds on the pepper weevil and pepper plant.

The work of two seasons, 1931 and 1932, is reported. The ¼-acre field plots were located at Downey, Calif.; all the other experiments were carried on at Alhambra, Calif. A total of 478 experiments, in which 9,560 weevils were used, were conducted in 1931; and 180 experiments, in which 3,600 weevils were used, in 1932.

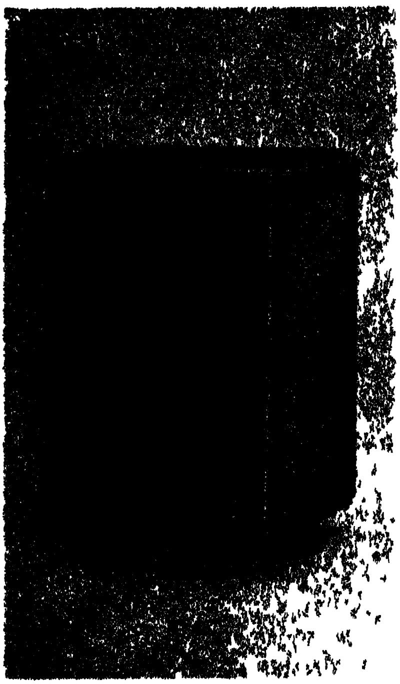

Fig. 96.—Cage used in tests of the relative effectiveness of fluorine compounds and calcium arsenate in control of the pepper weevil

PROCEDURE. *Mortality Tests.*—For the mortality tests individual, mature pepper plants growing in an outdoor plot were first given a thorough application of the material by blowing it with a duster through a hole in a large cloth cage which could be moved from plant to plant. After the dust had settled, this cage was removed and the soil around the plant was leveled off and covered with a square of wrapping paper. A weevil-tight screened cage 14 inches square and 19 inches high, with metal flanges on the inside of the base and extending below it for about 1½ inches, was then placed over each plant. (Fig. 96.) By wrapping cotton around the stem at the ground level, sealing the slit in the square of paper, as well as the hole around the stem, with gummed paper, and pressing the edge down firmly, all weevils were prevented from escaping and dead ones could easily be detected.

Dusting was done early in the morning and the weevils were introduced after the plants had been treated. Twenty adult weevils were released in each cage immediately after treatment and observations as to weevil mortality were made at 6, 12, 24, 36, 48, and 72 hours after the applications.

In 1931 the work was begun on July 23 and continued until October 7, and in 1932 it covered the period from August 22 to September 20. In

most cases parts of each series were done on different dates and under different temperature conditions.

Plant-Injury Tests. To determine the effect of these compounds on the pepper plants three types of tests were conducted.

In 1931 the materials were applied to ¼-acre field plots, field methods being used, under typical field conditions.

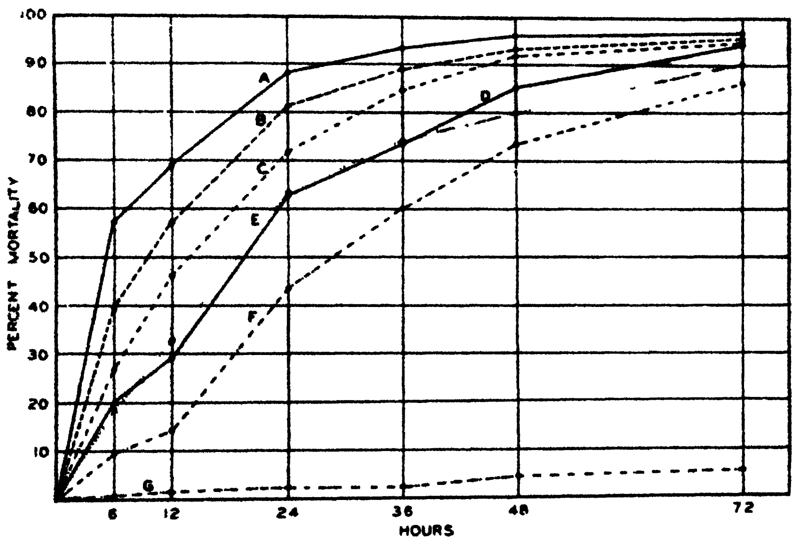

Fig. 97.—Mortality of the pepper weevil after treatments with several fluorine compounds and with calcium arsenate, experiments of 1931: (A) Sodium fluoaluminate, undiluted; (B) potassium fluoaluminate, undiluted; (C) barium fluosilicate, 80 per cent; (D) sodium fluoaluminate, 50 per cent; (E) calcium arsenate; (F) barium fluosilicate, 40 per cent; (G) untreated.

In 1932 greenhouse tests were made in which dust was applied in the same manner as in the mortality tests. Fifteen plants were treated with each material and the treatments were given every seven days from April 19 to June 9. Between May 17 and June 2 five plants in each set of 15 were wet morning and evening in order to duplicate outdoor conditions where heavy dews occur almost daily. Two dust applications were made after this wetting was begun. The results were determined by general observation and by counting the buds and pods on a given number of plants in each plot at definite intervals.

Later in the same season (July 9 to August 8) pepper pants were treated with various materials under natural outdoor conditions. Small test plots were dusted with a hand duster while long cloth panels were held on each side of the row to prevent the material from drifting to

other test plots. In this locality (southern California) the humidity is high at night and frequently moisture condenses on the plants. Since bud and pod setting has always seemed to be normal when calcium arsenate is used, this material was used as a check. The buds and pods were counted on every fifth plant in each plot on various dates. The initial count was taken as representing 100 per cent and the increase or decrease figured as percentage increase or decrease.

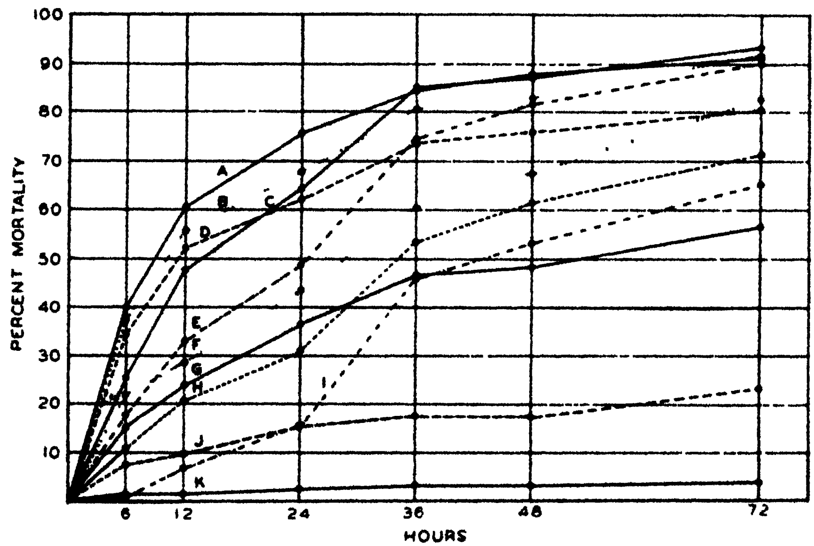

Fig. 98.—Mortality of pepper weevil after treatments with several fluorine compounds and with calcium arsenate; experiments of 1932. (A) Potassium fluoaluminate plus silicon dioxide, 50 per cent; (B) potassium fluoaluminate, 75 per cent; (C) potassium fluoaluminate plus silicon dioxide, 75 per cent; (D) sodium fluoaluminate plus silicon dioxide, 50 per cent; (E) calcium arsenate; (F) potassium fluoaluminate, 50 per cent; (G) ammonium fluoaluminate plus silicon dioxide, 50 per cent; (H) barium fluosilicate, 50 per cent; (I) calcium fluosilicate, 50 per cent; (J) magnesium fluoaluminate, 50 per cent; (K) untreated Talc was the diluent used in these materials.

Results, *Effect of Various Compounds on the Mortality of the Pepper Weevil.*—The relative toxicity of the various fluorine compounds used and of calcium arsenate is shown in Tables 1 and 2 and Figures 97 and 98.

In 1931 sodium fluoaluminate (synthetic cryolite) showed the highest mortality and 40 per cent barium fluosilicate the lowest. (Table 1 and Figure 97.) All the materials except 40 per cent barium fluosilicate and talc caused a higher mortality than did calcium arsenate. Sodium fluoaluminate at 50 per cent, however, was slightly below calcium arsenate at the 12, 24, and 36 hour periods. Natural mortality was very

low. On plants dusted with talc the mortality was slightly lower than on untreated plants.

TABLE 1. MORTALITY OF PEPPER WEEVILS OBTAINED AT THE END OF SPECIFIED PERIODS FOLLOWING TREATMENT OF THE PLANTS WITH CALCIUM ARSENATE AND WITH SEVERAL FLUORINE COMPOUNDS. BASED ON 208 EXPERIMENTS IN 1931 IN WHICH 4,160 WEEVILS WERE USED

Material	Number of experiments	Per cent mortality after specified number of hours: 6	12	24	36	48	72	Per cent missing
Calcium arsenate	25	18.4	32.7	63.4	74.0	80.0	90.4	4.0
Sodium fluoaluminate, undiluted	32	57.6	69.2	88.1	93.4	96.5	96.9	2.3
Sodium fluoaluminate, 50 per cent; talc, 50 per cent	27	20.0	29.4	63.0	73.5	85.2	94.4	2.5
Potassium fluoaluminate, undiluted	26	39.5	57.2	81.1	89.0	93.4	95.9	3.7
Barium fluosilicate, 80 per cent; inert material, 20 per cent	34	26.8	46.2	72.0	84.7	92.0	95.0	3.5
Barium fluosilicate, 40 per cent; talc, 60 per cent	34	9.7	14.0	43.8	60.0	75.4	86.3	4.4
Talc	8	1.2	3.1	3.1	3.1	3.7	4.3	0.0
Untreated	22	0.9	1.3	2.2	2.5	4.5	5.2	0.9

In the mortality tests in 1932 other fluorine compounds, as well as modifications of the same materials, were used, as indicated in Table 2

TABLE 2. MORTALITY OF PEPPER WEEVILS OBTAINED AT THE END OF SPECIFIED PERIODS FOLLOWING TREATMENTS WITH CALCIUM ARSENATE AND WITH SEVERAL FLUORINE COMPOUNDS. BASED ON 180 EXPERIMENTS IN 1932 IN WHICH 3,600 WEEVILS WERE USED

Material	Number of experiments	Per cent mortality after specified number of hours: 6	12	24	36	48	72	Per cent missing
Calcium arsenate	14	17.9	32.5	48.2	74.3	81.8	90.0	3.6
Potassium fluoaluminate plus silicon dioxide, 75 per cent; talc, 25 per cent	19	25.5	47.6	64.5	85.0	87.1	93.4	1.8
Potassium fluoaluminate plus silicon dioxide, 50 per cent; talc, 50 per cent	22	40.0	60.2	75.5	84.5	87.5	91.1	2.3
Potassium fluoaluminate, 75 per cent; talc, 25 per cent	19	37.4	55.5	67.6	80.5	82.9	91.6	3.9
Potassium fluoaluminate, 50 per cent; talc, 50 per cent	15	22.0	28.3	43.0	60.3	67.3	82.7	4.7
Sodium fluoaluminate plus silicon dioxide, 50 per cent; talc, 50 cent	26	34.0	51.7	61.9	73.6	75.6	80.6	1.9
Barium fluosilicate, 50 per cent; talc, 50 per cent	18	11.7	20.3	30.8	53.3	61.4	71.1	6.9
Calcium fluosilicate, 50 per cent; talc, 50 per cent	9	.5	6.6	15.0	46.1	53.3	65.0	2.2
Ammonium fluoaluminate plus silicon dioxide, 50 per cent; talc, 50 per cent	8	15.0	23.8	36.3	46.3	48.1	56.3	5.6
Magnesium fluoaluminate, 50 per cent; talc, 50 per cent	9	7.8	9.4	15.0	17.2	17.2	23.3	3.9
Untreated	21	1.4	1.9	2.4	3.1	3.3	3.6	—

and Figure 98. The data show that there was little difference in the effectiveness of the potassium and sodium compounds, but the barium, calcium, ammonium, and magnesium compounds showed a marked decrease in mortality in the order named.

Effect of Various Materials on the Pepper Plants. When the materials used in the mortality tests in 1931 were applied on ¼-acre field plots,

TABLE 3. RESULTS OF FIELD-PLOT TESTS WITH CALCIUM ARSENATE AND FLUORINE COMPOUNDS FOR CONTROL OF THE PEPPER WEEVIL, 1931

Dusting material	Diluent	Number of applications[1]	Number of plots	Per cent of infestation Aug. 12[2]	Average yield of peppers, pounds per acre	Effect on plants
Calcium arsenate	None	7	2	25.8	6,500	No injury
Potassium fluoaluminate	None	5	-	——	——	——————
Barium fluosilicate. .	Diatomaceous earth, 20 per cent	2	3	20.8	3,800	Light leaf burning, stunting, and bud pruning probable
Sodium fluoaluminate	None	7	3	28.4	3,400	Do.
Barium fluosilicate, 40 per cent	Diatomaceous earth 20 per cent; talc, 40 per cent	7	2	30.0	2,200	Leaf burning, stunting, and bud pruning light
Barium fluosilicate, 80 per cent	Diatomaceous earth, 20 per cent	7	2	11.7	1,800	Severe leaf burning, plants stunted and yellow, fruit odd-shaped and small
Untreated			4	48.2	1,200	———

[1]Made weekly, beginning July 22, 1931.
[2]Obtained by counting all buds and pods on 30 plants in each plot.

there was little change in effectiveness in reducing infestation. (Table 3.) Plant injury, however, overshadowed weevil control. Barium fluosilicate not only burned the leaves, but stunted the plants and very noticeably reduced the crop. Pods were off type in size, shape, and color. Sodium fluoaluminate caused slight leaf burning and some crop reduction. There was not enough potassium fluoaluminate used that year to determine its effect on the plants. With calcium arsenate, although the mortality was not so high as with some of the fluorine compounds, the yield of peppers was by far the highest. This was thought to be due to the fact that the fluorine dusts reduced pod setting.

In the tests in 1932 which were conducted in the greenhouse, the bud and pod counts varied so much that they were of no value in showing

comparative injury. General observations as to the condition of the plants after the treatments with each material are shown in Table 4,

TABLE 4. INJURY TO PEPPER PLANTS CAUSED BY CALCIUM ARSENATE AND FLUORINE COMPOUNDS; EXPERIMENTS OF 1932 CONDUCTED IN THE GREENHOUSE

Material	Number of plants	Number of applications on Dry foliage	Number of applications on Wet foliage	Injury
Barium fluosilicate, 50 per cent	10	7	-	Slight; yellow spots on leaves, buds damaged slightly.
	5	5	2	Pronounced; leaves yellow and burned, buds damaged.
Sodium fluoaluminate, 50 per cent	10	7	–	None.
	5	5	2	Pronounced; leaves yellow, buds damaged.
Ammonium fluoaluminate plus silicon dioxide, 50 per cent	10	7	–	Slight.
	5	5	2	Slight but definite, typical leaf and bud damage.
Sodium fluoaluminate, 50 per cent	10	7	–	None.
	5	2	2	Slight injury to leaves; bud injury doubtful.
Magnesium fluoaluminate, 50 per cent	10	7	-	None.
	5	5	2	Slight leaf yellowing only.
Potassium fluoaluminate plus silicon dioxide, 50 per cent	10	7	--	None.
	5	5	2	Slight bud pruning and leaf yellowing.
Calcium fluosilicate, 50 per cent	10	7	-	None.
	5	5	2	Slight bud pruning and leaf yellowing.
Calcium arsenate	10	7	--	None.
	5	5	2	None.
Talc, 50 per cent; diatomaceous earth, 50 per cent	10	7		None.
	5	5	2	None.
Untreated	10	–		None.
	5	-		None.

however. The observations were made without knowledge as to the kind of treatment the plant received.

In the tests conducted in the field in 1932 the appearance of the plants checked favorably with the bud and pod counts. (Table 5 and Fig. 99.) The plants treated with the 1931 sample of barium fluosilicate were severely burned. The plants treated with sodium fluoaluminate showed

definite bud and foliage injury for several days after the last treatment, and then apparently began to recover and to set buds rapidly The 1932

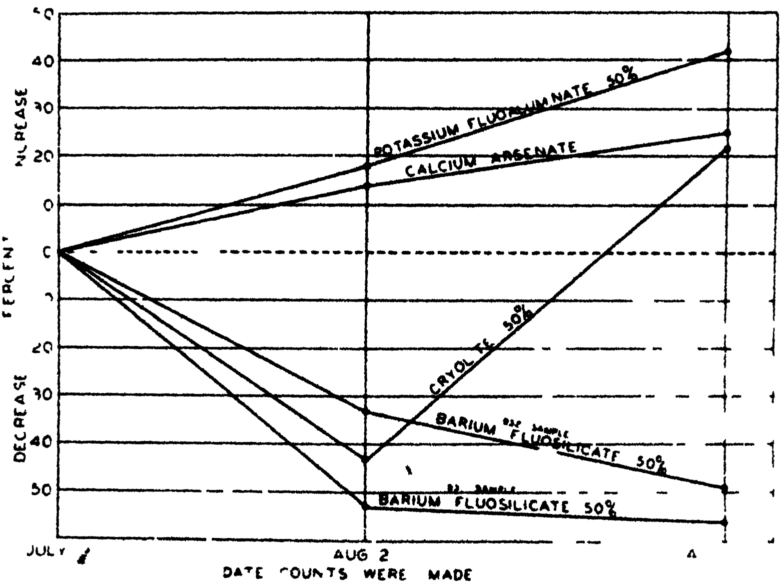

Fig 99 - Effect of several fluorine compounds as compared with calcium arsenate on the bud and pod setting of pepper plants

sample of barium fluosilicate showed less pronounced but definite injury Potassium fluoaluminate showed no injury of any kind either here or in field plots in four different areas

TABLE 5 EFFECT OF FLUORINE COMPOUNDS AND CALCIUM ARSENATE ON BUD AND POD SETTING OF PEPPER PLANTS WHEN TREATMENTS WERE GIVEN UNDER OUTDOOR CONDITIONS, 1932

Material	Treatment dates	Number of treatments	Total number of buds and pods on 10 plants in each plot: July 19	Aug 2	Aug 17	Percentage increase of buds and pods: Aug 2	Aug. 17
Calcium arsenate	July 9, 16, 23, August 1, 8	5	911	1,044	1,147	+14	+25
Potassium fluoaluminate, 50 per cent	July 9, 16, 23, August 1, 8	5	864	1,023	1,225	+18	+42
Sodium fluoaluminate (Cryolite), 50 per cent	July 9, 16, 23, August 1, 8	5	987	560	1,204	—43	+22
Barium fluosilicate, 50 per cent: 1932 sample	July 23, Aug 1, 8	3	1,250	838	637	—32	—49
1931 sample	July 23, Aug 1, 8	3	794	376	355	—53	—56

RELATIVE EFFECTIVENESS OF SINGLE AND DOUBLE TREATMENTS.—It was frequently noticed that materials that were giving good results in experimental plots, with thorough applications, were not controlling the weevils when used by growers. A study of dusting methods showed that the laborers usually employed for this work were doing it in a careless manner Hand dusters of the crank type were employed largely. Usually the nozzle was carried so near the tops of the plants that a heavy application was being made down the center of the row whereas the outer branches were untouched

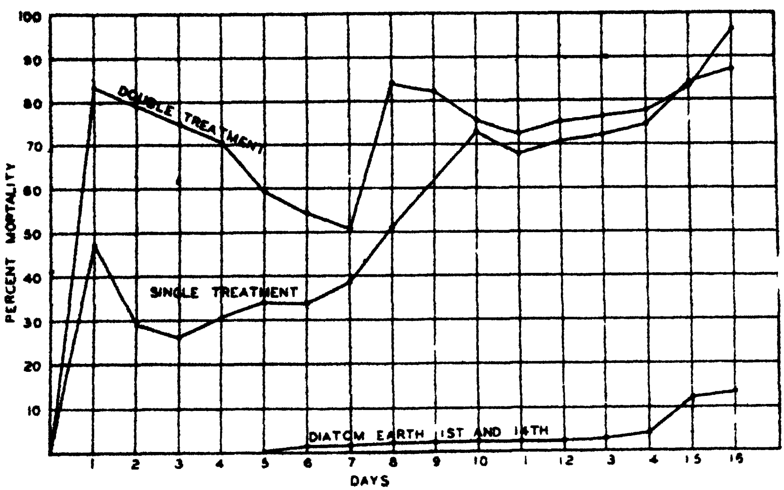

FIG. 100.—Mortality of the pepper weevil resulting from single and double treatments with a mixture of 70 per cent sodium fluoaluminate, 25 per cent diatomaceous earth, and 5 per cent hydrated lime, and with diatomaceous earth alone.

In order to determine if the method of dusting had any influence on the effectiveness of the treatments, two series of cages were set up. In one series 19 plants were given a single treatment in the manner just described, and in the other 12 plants were dusted first on one side of the row and then on the other. A mixture of 70 per cent sodium fluoaluminate, 25 per cent diatomaceous earth, and 5 per cent hydrated lime[4] was used as the dusting material. About 8 pounds per acre were put on in the first case and 16 pounds in the second Applications were made at 7-day intervals, and two weevils were introduced in each cage each day for 10 days to represent a continuous reinfestation. As a check five plants

[4]Lime was added to determine if it would reduce the effectiveness of sodium fluoaluminate.

were treated with undiluted diatomaceous earth on the first and fourteenth days and three were left untreated.

The results of this experiment are shown in Figure 100 and, for the treatments with the sodium fluoaluminate mixture, in Table 6. It will

TABLE 6. SUMMARY OF RESULTS OF SINGLE AND DOUBLE TREATMENTS WITH A MIXTURE OF 70 PER CENT SODIUM FLUOALUMINATE, 25 PER CENT DIATOMACEOUS EARTH, AND 5 PER CENT HYDRATED LIME

Date of dusting	Date of weevil introduction	Number of weevils introduced each day	Total number of weevils introduced	Total number of dead weevils	Per cent mortality[1]
Single treatments, results based on 19 experiments					
Sept. 16	Sept 16	38	38	18	47
	17	38	76	22	29
	18	38	114	30	26
	19	38	152	47	31
	20	38	190	65	34
	21	38	228	78	34
	22	38	266	102	38
Sept. 23	23	38	304	204	67
	24	38	342	250	73
	26	38	380	258	68
	27	0	380	268	71
	28	0	380	274	72
	29	0	380	283	74
Sept. 30	30	0	380	321	84
	Oct. 1	0	380	332	87
Double treatments, results based on 12 experiments					
Sept. 23	Sept 23	24	24	20	83
	24	24	48	36	75
	26	24	72	51	71
	27	24	96	57	59
	28	24	120	65	54
	29	24	144	73	51
Sept. 30	30	24	168	142	84
	Oct. 1	24	192	158	82
	2	24	216	163	75
	3	24	240	175	73
	4	0	240	181	75
	5	0	240	184	77
	6	0	240	186	78
Oct. 7	7	0	240	201	84
	8	0	240	231	96

[1]The per cent mortality was determined by comparing the total number of weevils dead on each date with the total number that had been introduced.

be noted that with the double treatment the mortality curve was well above 50 per cent while with the single treatment it remained below that point until after the second application on the seventh day. Close observations indicated that this was largely because the double treatment gave a thorough covering of all the foliage. After the tenth day, and especially after the third application on the fourteenth day, the

mortality in both cases approached 100 per cent, probably because no weevils were introduced after the tenth day. Diatomaceous earth caused some killing, but it was more pronounced after the second application on the fourteenth day, when the weevils were dusted as well as the plant. The natural mortality on untreated plants (not shown in the chart) was only 1.5 per cent on the eleventh day and 3.3 per cent at the close of the experiment.

SUMMARY.—Sodium fluoaluminate, potassium fluoaluminate, and barium fluosilicate at dilutions as low as 50 per cent and calcium arsenate at full strength were all found to be effective against the pepper weevil when applied under controlled cage conditions with a known number of adult weevils. Sodium and potassium fluoaluminates were the most effective materials used. Barium fluosilicate, while showing marked effectiveness at concentrated strengths in 1931, gave rather low results when diluted to 50 per cent. Although effective as a weevil control, this material not only burned the leaves but caused stunting and yellowing of the pepper plants. Plants dusted with sodium fluoaluminate in the presence of moisture exhibited leaf injury and bud pruning but did not appear unusually yellow or retarded in growth. Both barium fluosilicate and sodium fluoaluminate caused crop reduction in field plots in 1931. Of the fluorine compounds found to be satisfactory for the control of the pepper weevil, potassium fluoaluminate was the least toxic to the plants.

In the absence of moisture under greenhouse conditions barium fluosilicate was the only fluorine compound causing definite injury. Sodium and potassium fluoaluminate samples containing small quantities of silicon dioxide caused less injury in the greenhouse on wet plants than did the unmodified sodium fluoaluminate.

A series of experiments in which one group of plants was doubly treated, once down each side of the row, and another group was dusted down the center of the row showed that an effective insecticide carelessly applied in the field may not cause so high mortality of the weevils as a less effective material more carefully applied.

The results of this work bring out the fact that fluorine compounds are injurious to pepper plants, and because of this and also the residue problem they are not to be recommended as a control for the pepper weevil.

EFFICIENT AGITATION IN THE SPRAY TANK

By Arthur D. Borden, *Assistant Entomologist, University of California*

Abstract

In testing over 200 spray outfits the agitation in the spray tank was found to be decidedly inefficient. The propeller type agitators at speeds less than 200 rpm do not give a uniform mixture. A new type square end agitator gives excellent results at speeds from 88 to 110 rpm and a low hp consumption. It is recommended that this type of agitator replace the propeller type.

The agitation in the standard spray equipment is decidedly inefficient. In testing over 200 spray outfits, including such makes as the Bean, Hardie, Hayes, Myers and Friend, very few have given a uniform mixture of the insecticides used. With the propeller type of agitators with which most of these outfits are equipped the rpm of the agitator shaft is by far too low to give efficient results. Even in those using the larger type of blades such as the Bean and Hardie, the practice of having only two such agitators in a 200 gallon tank or three in a 300 gallon tank at a speed of from 86 to 120 rpm, does not produce a uniform mixture throughout the delivery from the pump. The last fifty gallons of spray often have a concentration of from ten to twenty times that delivered when the tank is full.

The matter of uniformity of mixture is most important in the tank mixture method of preparing oil sprays and also of considerable importance in the application of such materials as lead arsenate, sulfur and the heavier types of commercial oil emulsions. Too frequently do we find that the last few trees sprayed with the last of the spray from a tank of lead arsenate receive a much heavier deposit of lead arsenate than do the trees sprayed with the first fifty gallons from the same tank. This not only affects the efficiency of the coverage from the standpoint of toxicity but also may greatly affect the residue removal problem, especially on the fruit receiving an excess deposit due to improper concentration.

This matter of efficient agitation was first developed by Dr. Ralph Smith in his work with the tank mixture method of spraying citrus in southern California (Bulletin 527, University of California). He has shown that a uniform mixture may be obtained with either four of the small type Hardie, two of the large Hardie or 2–3 bladed Bean agitators in a 200 gallon tank if 200 rpm are developed on the agitator shaft. With these propeller type agitators speed of agitation is more essential than the increase in number of agitators used. This combination required about .5 hp which is relatively negligible in the case of motors of

8 hp and above By simply changing the gear ratio between pump and agitator shaft the desired speed can be obtained

In developing the tank mixture method of oil spraying on deciduous fruits in northern California, the writer has found that this increased speed with the demand for additional energy is often difficult to obtain Much of our equipment has comparatively low powered motors (2.5 to 8 hp) with 200 and 300 gallon tanks and it is with difficulty that 300 lbs pressure can be maintained when both lines of hose are operating To further tax the motor with this high speed agitation is often impossible Furthermore it is often difficult and expensive to obtain the desired gears for the change over

A new type of agitator has made it possible to obtain the desired uniform mixture without increasing the speed of the agitator shaft and using but a minimum amount of energy This agitator is a 2 bladed, flat square end piece of $\frac{3}{16}$ inch steel with the following dimensions

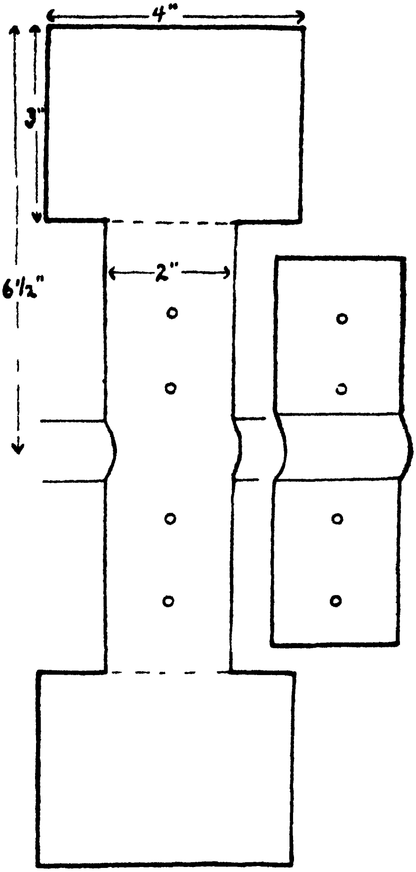

Fig. 101 – Pattern of flat square end propeller

Length over all	13 inches
Shank	2 inches wide
Groove to fit shaft	1 inch
End plates at right angles to shank	3 x 4 inches
Binding plate with groove for shaft and four $\frac{3}{8}$ inch bolt holes	2 x 6 inches

The end plates may be made any desired length (4" 6" 8") from 3" material and are best welded to the ends of shank

Tests conducted in the laboratories of the Agricultural Engineering Division at Davis have shown that in a 200 gallon Hardie tank uniform mixtures were obtained with four of these 3" x 4" agitators at 88 rpm, with but a 2 hp consumption Adding two of these flat square end

agitators to 2 large Hardie agitators already in the tank gave a uniform mixture at 109 rpm with less than .2 hp consumption.

In a 300 gallon Bean tank with 3–3 bladed Bean and 4–3" x 8" square end agitators a perfect test was obtained at 96 rpm.

These new type agitators may be made on the ranch or by a local blacksmith at a cost of approximately half of the other type and considering their efficiency should replace all other types of agitators.

In some spray tanks the agitator shaft is too close to the bottom of the tank to permit any adequate type of agitator to be applied. In such cases it is necessary to raise the shaft so as to permit at least 7½ inch clearance between shaft and bottom of tank.

Another type of agitator has also proven very efficient. It may be called the 'reel' type and is composed of two 1½ inch strips of steel or wood spaced within clearance distance of the bottom of the tank on either side of the shaft The length of these strips is the inside length of the tank. Two or three cross members bind these strips to the shaft At a speed of 96 rpm this agitator gave a perfect test in a 200 gal. Hardie tank. In tanks having overhead suction system or rods to strainer, the reel must end within a few inches of such device and a square end agitator can be used between the end of tank and suction line or rod.

Due to the greater efficiency of the flat square end agitators over the propeller type, it is recommended that for efficiency the new type agitator displace all others. It is better to have a complete set of the new type than to mix them with the less efficient propeller type.

NOTES ON THE LIFE HISTORY OF THE APPLE MAGGOT IN WISCONSIN

By T. C. Allen and C. L. Fluke, Jr.*

Abstract

Studies of the seasonal emergence of the apple maggot (*Rhagoletis pomonella*) during 1932 showed that over 37 per cent of the flies emerged from two-year old pupae. The peak of the emergence of these flies occurred eight days later than the normal brood which affected timing of sprays. Yeasts dried at 70–80° F., powdered and mixed with 3 or 4 parts of honey proved considerably more successful for rearing the adult fly than did yeast and honey when water was added.

During studies of the life history of the apple maggot at Gays Mills, Wisconsin, it was noted that a relatively large brood of flies emerged in

*Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

1932 from two-year old pupae. These flies emerged later than flies which spent one winter in the soil and showed a distinct peak of emergence comparable to a second brood of adults. The late emergence of flies from these two-year pupae accounted for the late appearance of many flies in the orchard.

A number of workers have reported a two year cycle of the apple maggot. Their observations indicate that a small per cent of the flies ordinarily require two seasons to complete their life cycle. Lathrop and Nickels[1] found a two and a three season carry-over of flies in studies of the blueberry maggot recently described as *Rhagoletis mendax* by Curran[2] which emerged later than flies that spent only one season in the soil. These workers noted that the carry-over of flies in one instance amounted to 19.68 per cent. Studies on the apple maggot under Wisconsin conditions have shown a maximum of 37 per cent carry-over for two years. The fact that a large proportion of the apple maggot-flies may not emerge until a second season is significant in the control of this insect.

Apple maggot adults which emerge from pupae that remain in the soil for a period of two seasons are of an economic importance at Gays Mills, Wisconsin A distinct emergence peak of such flies occurring later in the season than normally obviously affects a spray program designated for earlier emerging insects. Two sprays, one for each brood of flies, have been therefore recommended in seasons of a heavy carry-over. The first spray is applied before the peak of the normal emerging flies has been reached. The second spray is applied previous to the peak of the carry-over brood which occurs 8 to 12 days later Lead arsenate at the rate of one pound to fifty gallons of lime sulfur spray, when applied as suggested above, controlled the apple maggot.

Methods and Results.—The time of emergence of maggot-flies was determined by the usual method, by making daily counts of emerging flies from overwintering hibernation cages. The cages used in 1929 were made of wooden frames of 1 by 8 inch boards, 3 feet wide, and 10 feet long and were set securely on the surface of the soil. The tops of these frames were enclosed with wire screening, except for a small opening to which was attached a smaller wire cage to collect the flies. A black paper covering placed over the frames for a brief interval before

[1]Lathrop, F. H. and Nickels, C. B. 1932. The Biology and Control of the Blueberry maggot in Washington County. U. S. D. A. Bur. Ent. Tech. Bull. 275, pp. 1–77.

[2]Curran, C. H. 1932. North American Diptera, With Notes on Others. Amer. Mus. Novitates No. 526, pp. 1–13.

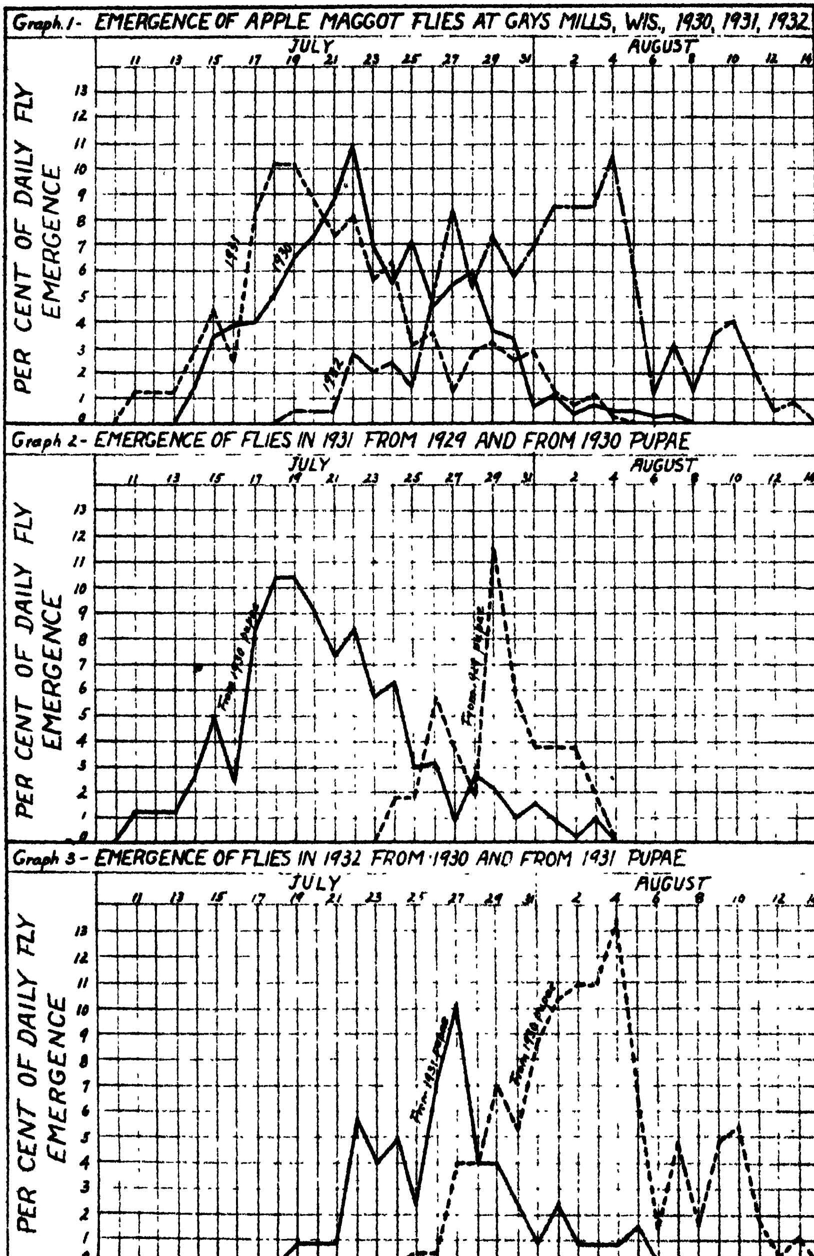

FIG. 102.—Apple maggot emergence.

collecting aided in inducing the flies to enter the smaller cages. The cages were located in the orchard where they were partly shaded by apple trees and approximately six bushels of several varieties of maggot-infested apples were put in each cage.

A larger number of cages were employed in 1930 and 1931. Nineteen cages, 2 by 3 feet in size were used. They were constructed similar to those described above and were placed in the orchard at various locations under the trees. Each of these cages contained only one variety of maggot-infested fruits and were prepared as each variety matured. All cages were enclosed with wire screening and since no infestation of apple maggot occurred in the immediate vicinity of the cages, it was assumed that no maggots or maggot infested fruit entered the cages to affect the results.

The accompanying graphs in figure 102, show the daily emergence in per cent of 13,680 flies over a period of three seasons Graph 1 represents the total seasonal adults taken from hibernation cages in 1930, 1931 and 1932 In graph 2, a comparison is made of the emergence of one year and of two year carry-over flies Slightly more than 7 per cent of the flies from 1929 pupae emerged in 1931 Their emergence however, showed a peak which occurred 11 days later in the season than the peak of the one year flies The percentage carry-over this season is not of considerable significance Graph 3 compares the emergence of flies in 1932 from one and from two year old pupae The collections of flies in 1932 showed that 37 per cent of the adults from 1930 pupae emerged in 1932 The emergence peak of this season's carry-over occurred 8 days later than the one year brood

The large two-year brood of apple maggots in 1932 at Gays Mills had emerged from pupae that remained in the soil during the hot and dry summer of 1931. This abnormally warm season in the absence of much moisture at time of fly emergence undoubtedly accounted for such delayed emergence. During this season, infestation of the apple maggot was also noted to be relatively light The flies that had emerged were observed to be affected considerably from the heat and lack of moisture. They succumbed readily both in the insectary and under natural conditions in the orchard The ability of the apple maggot to remain in the soil during seasons of unfavorable conditions has an important bearing upon the survival of the species.

IMPROVED REARING MIXTURE.—The use of honey-water and yeast as a food in rearing the apple maggot[3] has given more favorable results

[3]Fluke, C. L. and Allen, T. C. 1931. The Role of yeast in life history studies of the Apple Maggot, *Rhagoletis pomonella* Walsh. Jr. Ec. Ent. 24: 1, pp. 77–80.

when the water is omitted. Flies fed ravishly upon honey to which four parts of powdered dead yeast cells were added, and gravid females developed as early as 9 days. Copulation occurred as late as 76 days. Red Star yeast dried at 70 to 80 degrees F. and powdered and mixed with honey furnishes considerably more protein material when water is absent since fermentation is prevented. A smear of this mixture upon the sides of the container in which flies are reared, remains several days and will not ferment unless diluted with water. Water is necessary however, and was supplied to the containers separately twice daily. Lamp chimneys in which were placed apples for oviposition served as rearing cages, and two broods of this insect were reared in the laboratory during December, January and February.

FIELD STUDIES WITH PINE OILS AS DESTROYERS OF OVERWINTERING CODLING MOTH LARVAE[1]

By F. M. Thompson, Jr. *Research Assistant, Rutgers University*
and
H. N. Worthley, *Pennsylvania Agricultural Experiment Station*[2]

Abstract

A blend of various fractions of steam-distilled pine oils was found to be effective in field applications against hibernating codling moth larvae (*Carpocapsa pomonella*) when brushed liberally upon the rough bark, crotches, pruning wounds, and cankers of apple trees. The applications produced marked reduction in the amount of first brood codling moth injury in the treated blocks, without injury to the trees. Fruit counts at harvest indicated that the initial advantage gained by the treatment will produce the greatest benefit when large areas are treated at the same time, and followed by the recommended codling moth cover sprays.

In the fall of 1930 a study of the various steam-distilled pine oils was undertaken in an attempt to develop a spray which would be effective in killing codling moth larvae overwintering on the trunks of apple trees. An efficient formula was developed, but the mixture proved to be injurious to apple buds. When diluted with equal parts of water it could be brushed onto the rough-barked areas of the trunk and larger limbs,

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Entomology.

Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 574.

[2]The preliminary investigation leading to the development of the formula was the work of the senior author, who also planned and supervised the field tests in New Jersey. The field test in Pennsylvania was planned by the junior author, and supervised by both. The fruit counts and the preparation of this paper were done jointly.

but it was imperfectly miscible, and was abandoned in favor of the idea of developing a paint that could be applied to the trunks in a concentrated form.

Considerable time was spent in the search for fractions of pine oil which could be used on the trunks of the trees without injury, but which would at the same time be toxic to codling moth larvae. When these fractions were found, it was necessary to blend them into a mixture possessing the desired physical properties. Finally a formula was developed which consisted of a blend of several fractions, with a heavy non-volatile oil as a base. The trade name HYBREX has been given to this material, and will be used for convenience in this paper.

The physical properties of "Hybrex" are such as to allow it to be applied with a brush to those parts of an apple tree that shelter the great majority of codling moth larvae; e. g., the rough-barked areas of the trunk and limbs, narrow crotches, split limbs, cankers, old pruning scars, etc. When applied with thoroughness and in sufficient quantity it runs beneath the bark scales, and penetrates into cracks and rotting stubs. Codling moth cocoons soak it up readily, and the larvae are killed on contact. It is the purpose of this paper to present the results of block treatments with this material during 1932.

METHODS.—In the spring of 1932 arrangements were made to "oil" the trunks of several hundred apple trees in an orchard near Glassboro, New Jersey. Four blocks were laid out in this orchard, as follows:

Block 1. Stayman—32 rows of 14 trees each.
- 8 rows untreated.
- 8 rows scraped and banded.
- 8 rows "oiled" with "Hybrex".
- 8 rows untreated.

Block 2. Winesap—24 rows of 14 trees each.
- 8 rows untreated.
- 8 rows scraped and banded.
- 8 rows "oiled" with "Hybrex".

Block 3. Rome Beauty—100 trees, 10 x 10.
- 42 trees (7 x 6) at the center "oiled" with "Hybrex". Remainder of trees untreated.

Block 4. Mixed varieties—100 trees, triangular planting.
- Half the block untreated.
- Half the block "oiled" with "Hybrex".

A fifth block was laid out in an orchard at McKnightstown, Adams County, Pennsylvania.

Block 5. York Imperial—30 rows of 15 trees each.
- 15 rows untreated.
- 15 rows "oiled" with "Hybrex".

In blocks 1 to 4 the oiling was done in April, when the trees were in the "pink-bud" stage. The trees in the Glassboro orchard were 15–18 years old. Those in block 3 had developed little rough bark, so that it was not necessary to use much oil except in the crotches and on pruning scars and cankers in the tops of the trees. The oil was applied by means of a round brush about 3 inches in diameter, with bristles 2–3 inches long, mounted at an angle on the end of a broomstick. The banded rows were scraped in the spring, and the scrapings burned. Bands were applied in June.

In block 5 the oiling was done May 4 to 6, when the trees were in full bloom. The trees in the Pennsylvania orchard were 25–30 years old. They presented large areas of rough bark, many pruning stubs, and cankers caused by egg-laying punctures of the periodical cicada. The treatment in this block required an average of 3 pints of oil per tree, and took 20 minutes per tree to apply. The operation is illustrated on plate 55, figures 1 and 2.

RESULTS.—Several oiled and untreated trees in the Glassboro orchard were carefully examined by the senior author a few days after the application. Living and dead larvae were recorded. The data are set forth in Table 1.

TABLE 1. EFFECT OF "HYBREX" ON HIBERNATING CODLING MOTH LARVAE. GLASSBORO, N. J., 1932

Treatment	Number trees examined	Number larvae found	Number larvae dead	Per cent larvae dead
Hybrex[1]	2	118	113	95.8
Hybrex[2]	9	181	107	59.1
Untreated	8	118	32	27.1

[1]Trees treated by senior author.
[2]Trees treated by inexperienced laborers.

Table 1 clearly shows the effectiveness of the treatment, and also the need for thoroughness and good judgment in its application. No more time nor material were expended to procure the higher kill. The workmen employed were simply inexperienced in orchard operations, and knew little or nothing about the codling moth and its habits.

No detailed examination of trees was made in the Pennsylvania orchard. The men employed here were experienced orchard hands, familiar with the hiding places of codling moth larvae. In checking

EXPLANATION FOR PLATE 55.

1—The "brush" method of treating apple trees to kill hibernating codling moth larvae.

2—Apple trunk and pruning stubs after brush treatment with pine oil blend.

3—Codling moth larvae killed in their cocoons by pine oil treatment.

1 2 3

back over their work few living larvae were found. Several of the dead larvae are pictured on plate 55, figure 3.

The toxicity of "Hybrex" to codling moth larvae had been determined by the investigation upon which the formula was based, and was confirmed by the field counts reported in Table 1. The main purpose of the block treatments was to discover the effect on the fruit of the reduction in codling moth population obtained by such pre-season treatment. Any reduction in population should produce a reduction in the number of codling moth injuries, particularly those produced by the first brood of larvae. Drift of first brood moths into treated blocks would tend to obscure the results. Accordingly, the first fruit counts were made after the attack of the first brood larvae had ceased, but before many second brood larvae had hatched.

In the New Jersey orchard three trees were selected at the center of each treatment. One hundred apples from the top and 100 from the bottom of each tree were scored for codling moth injury. In the Pennsylvania orchard 5 trees at the center of each treatment were used, and 50 apples from the upper and 50 from the lower branches were examined. Table 2 presents the results of these counts.

TABLE 2. INJURY BY FIRST BROOD CODLING MOTH LARVAE IN TEST BLOCKS

	Treatment	Number of apples Counted	Number of apples Injured	Per cent Injured	Injuries Total Per cent	Injuries Reduction
Block 1	Untreated	600	292	48.6	611	—
	Scraped	600	258	43.0	470	19.9
	Hybrex	600	236	39.3	382	34.9
	Untreated	600	278	46.3	563	—
Block 2	Untreated	600	249	41.5	506	—
	Scraped	600	174	29.0	246	51.4
	Hybrex	600	130	21.6	170	66.4
Block 3	Untreated	600	187	31.1	371	—
	Hybrex	600	103	17.1	131	64.7
Block 4	Untreated	600	213	35.5	337	—
	Hybrex	600	180	30.0	233	30.9
Block 5	Untreated	500	271	54.2	556	—
	Hybrex	500	192	38.4	315	43.3

The infestation figures in Table 2 would have been much lower in all blocks had recommended spraying practices been followed. Spraying practices were uniform in the blocks under comparison, but in both orchards the timing was poor and important cover sprays were omitted. In addition, block 5 received only about one-fourth the recommended amount of spray material per tree per application. However, as the

table clearly shows, the pre-season treatments given were of considerable value in reducing the number of injuries to the fruit, even in the comparatively small blocks of trees used.

Fruit counts were made at picking time only in blocks 2 and 5. Block 1 had such a light set that in the absence of adequate spraying treatment all the fruit was injured. The treated portion of block 3 was so small that moth migration during the summer obscured the earlier beneficial results. Due to a mistake, block 4 was picked before counts had been made.

Harvest counts were made on the trees used earlier in the season. In block 2, 100 apples were taken from the top of each tree, 100 from the bottom, and 25 dropped fruit from the ground. In block 5, 50 apples were taken from the top, 50 from the bottom, and 50 from the ground. In both orchards the dropped fruit was included in the counts in their estimated proportion to the total crop. The results of these counts are shown in Table 3.

TABLE 3. CODLING MOTH INJURY IN TEST BLOCKS AT HARVEST

	Treatment	Number of apples Counted	Number of apples Clean	Per cent Clean	Injuries Total Per cent	Injuries Reduction
Block 2	Untreated	675	69	10.2	2,782	—
	Scraped and banded	675	254	37.6	915	67.1
	Hybrex	675	263	38.9	918	67.0
Block 5	Untreated	750	179	23.8	1,418	—
	Hybrex	750	228	30.4	1,144	19.3

By comparing Tables 2 and 3 it will be noticed that in block 2 the section treated with "Hybrex" maintained the advantage gained earlier in the season, and that the banding improved the total effect of the scraped section by preventing heavy emergence of first brood moths. These two treatments showed almost identical results by the end of the season.

In block 5, however, the early season advantage indicated in Table 2 was largely lost by picking time. This result was expected. It was due to poor spraying practices which allowed a high proportion of the first brood larvae to develop. Stimulated by a poor set of fruit, many first brood moths migrated into the oiled section from heavily infested blocks on three sides. It seems obvious that the greatest benefit can be derived from the pine oil treatment only when all badly-infested blocks in a given orchard area are treated in the same year, and the treatment followed by the recommended program of codling moth cover sprays.

During the time of treatment, "Hybrex" was applied to the following varieties: Rome Beauty, Stayman Winesap, Winesap, York Imperial,

King David, Gano, Early Ripe, Paragon, and Maiden Blush. Some of these trees have had applications in two successive years, but in no case has any injury from the use of this material appeared. It is felt certain that one application of the oil will cause no damage. It should not be applied to new pruning wounds, for the tissue will be killed back. It is also injurious to the buds.

SUMMARY AND CONCLUSIONS.—A blend of steam-distilled pine oil fractions named "Hybrex" was effective in reducing codling moth population in apple orchards when thoroughly painted on the areas of rough bark, crotches, pruning scars and cankers. These areas must be *thoroughly wet* with the material. It may be applied with a long-handled brush, the brush being round, about three inches in diameter, with bristles from two to three inches long.

"Hybrex" may be used on the trunks and branches of apple trees for at least one year with safety. It should not be applied to new pruning wounds or buds.

Blocks of apple trees treated with "Hybrex" have exhibited from one-third to two-thirds the number of first brood codling moth injuries occurring in adjacent untreated blocks. Proper application of the recommended cover sprays is essential if this advantage is to be maintained throughout the season.

INVESTIGATIONS REGARDING BLUE GRASS WEBWORMS IN TURF[1]

By H. F. A. NORTH, *Assistant Research Professor of Agronomy at the Rhode Island Agricultural Experiment Station*, and G. A. THOMPSON, Jr., *Inspector of the Department of Entomology of the Rhode Island State Department of Agriculture.*

ABSTRACT

During 1930-1932 a number of insecticides were tested on webworm infested putting green plats. The species of importance was found to be the Blue Grass Webworm (*Crambus teterellus*). Velvet bent (*Agrostis canina*) was found to be damaged more heavily during 1931 and 1932, than the other species of bent grass and similarly some of the varieties of velvet bent were damaged more heavily than others.

The damage was reduced considerably by the use of arsenate of lead, Paris green or a trade brown patch remedy and soil insecticide; reduced moderately by flooding with dilute pyrethrum extracts and an extract of rotenone; and only reduced slightly by the use of kerosene emulsion. Arsenate of lead 2 pounds in 20 gallons of water per 1,000 square feet of turf is regarded as a very promising remedy.

Rather severe damage to golf turf during late years has been caused by

[1]Published by permission of the Director of the R. I. Agricultural Experiment Station, Kingston, R. I., as Contribution No. 437.

webworms (*Crambus* species). This damage may give a putting green the appearance of a moth-eaten rug and reduce the putting properties proportionately.

Although webworms or close-winged moths have been described by entomologists for over 100 years, but little definite knowledge of the best means for control in fine turf seems to have been published until recently. For this reason a test was begun during 1932 at the Rhode Island Agricultural Experiment Station with certain promising materials in order that the bluegrass webworm (*Crambus teterellus*) in demonstration plats might be held in check. The test has been successful in showing differences in the control properties of eight insecticides.

Ainslie,[2] in 1930, published a comprehensive account of the natural history of the bluegrass webworm (*Crambus teterellus*) Briefly he stated that the webworm may prefer Kentucky bluegrass but will readily feed upon other kinds of grass. The bluegrass webworm was found to be widely distributed over the southern two-thirds of the eastern part of the United States In dry seasons they may be the real cause for complete killing of sod in pastures and lawns The larva was found to be the over-wintering stage There were found to be three broods of moths annually, most abundant during May, July, and September. The moths were described briefly as small, light gray, and with wings folded closely around the body when at rest. They were found to become active about dusk, to be attracted to light in large numbers, to feed only upon water, and after mating to lay approximately 200 to 250 eggs, apparently dropped in flight. Moths are said to live from 7 to 10 days. Eggs hatch into larvae in a similar period and the larvae very rapidly migrate down to the soil level Here a runway is fashioned from particles of earth or vegetable matter fastened together with silk, in which the worm remains during the day and from which it feeds upon the basal part of the leaves. After from 10 to 14 days in the pupa stage the moths appear. Young succulent growth is preferred and feeding is most active on cloudy days and during the night. No control measures were tried by Ainslie, but it was his opinion that large quantities of moths could be taken with light traps.

A reference to the life history and control of the webworm was published in 1932 by Noble.[3] As regards the natural history it was stated

[2]Ainslie, G. B. The Blue Grass Webworm. U. S. D. A. Tech. Bul. 173, 1930. Abstract published in the Bulletin of the U. S. Golf Assoc., Green Section for June, 1930.

[3]Noble, W. B. Sod Webworms and their Control. Bulletin of the U. S. Golf Assoc., Green Section, 1932. 12 (No. 1): 14–19.

that only some 12 species of webworm are economically important and that their habits are similar. Noble stated also that many of the larvae were eaten by birds. Materials reported by Noble as practically 100 per cent effective were pyrethrum extracts and kerosene emulsion when diluted with water and applied by means of a sprinkling can. The extracts were diluted at 1⅓ to 1⅔ pints to 111 gallons of water per 1000 square feet of turf. The stock solution of the kerosene emulsion was prepared by beating ½ gallon of kerosene into a solution of 1 pound of laundry soap in 1 gallon of boiling water. It was found that an application of 2 1/5 gallons of the stock solution in 111 gallons of water per 1000 square feet of turf was very effective The pyrethrum extracts, as well as the kerosene emulsion, brought the webworm larvae to the surface in a few minutes where they soon died Noble reported also that arsenate of lead dusted on at 7½ pounds per 1000 square feet of turf, well brushed and watered in, was found approximately 30 per cent effective. The relative costs of these materials per treatment, as stated, was computed at $4 00 for the pyrethrum extracts, 20 cents for kerosene emulsion, and $1 10 for arsenate of lead This author mentions that arsenate of lead at 2 pounds in 15 gallons of water used as a spray has been recommended but that this treatment was not tested by him.

WEBWORM DAMAGE TO VELVET BENT VARIETIES, 1930 TO 1932.—In 1930 the demonstration putting-green plats of velvet bent grass at the Rhode Island Agricultural Experiment Station showed a rather general moth-eaten appearance during July and again in September. It was found to be due to webworms Dusting with four parts of lime to 1 part of arsenate of lead as used on cabbage was not found to be effective.

In 1931 damage occurred again only on the velvet bent varieties and again the moth-eaten appearance was most pronounced in July and September. A poison bait was spread over the plats without result except damage to the turf from the Paris green which it contained. In August an application of a pyrethrum extract was used at approximately 1¼ pints (plus soap) per 40 gallons of water per 1000 square feet. A fair control was obtained and a moderate number of webworms were brought up. Since the damage from the webworms caused the plats to become unsightly again in September, a spray of 4 parts of lime to 1 part of arsenate of lead was applied at approximately ½ pound of the arsenate per 1000 square feet. The latter application was not effective.

Although the materials tried had been mainly ineffective during 1930 and 1931, the facts became increasingly evident that only the velvet bents were noticeably damaged and that some varieties of velvet bent were damaged more than others. Evidence may be had in Table 1 of the

difference in damage between pure velvet bent as compared with colonial velvet bent mixtures. The difference in resistance between the plats of

TABLE 1. PER CENT OF AREA DAMAGED BY BLUEGRASS WEBWORMS AMONG VELVET BENT VARIETIES SHOWING DIFFERENCES IN DAMAGE WHEN MIXED WITH COLONIAL BENT AND WHEN PURE, THE SIMILARITY IN DAMAGE IN 1931 AND 1932, AND THE SEASONAL CHANGE IN 1932

Varieties of velvet bents in putting green turf	Method and year of planting	Per cent pure velvet bent 1932	Damage 1931 season	Per cent of area damaged by webworms in 1932: July 30	Aug. 29	Sept. 30	Oct. 30	Average
	1928							
Kernwood*....	Stolons	99.5	Heavy	9	20	9	4	10.5
Highland.....	Stolons	99.5	Heavy	7	2	10	3	5.5
Newport......	Seed	60.0	Medium	5	1	1	1	2.0
German bent..	Seed	15.0	Light	0.5	0.5	0.5	0	0.4
	1929							
Acme.........	Stolons	95.0	Heavy	10	3	5	3	5.2
B.P.I. 14276†.	Stolons	99.5	Medium	3	3	8	2	4.0
Mountain Ridge	Stolons	99.5	Medium	2	0.5	10	2	3 6
	1930							
Yorkshire*....	Stolons	99.5	Heavy	25	25	35	16	22.7
Newport	Stolons	98.0	Heavy	10	2	15	2	7.5
Oregon-grown.	Seed	5.0	None	0	0.5	1	1	0.6
	1931							
Cunningham..*	Stolons	98.0		0.5	0.5	25	4	7.5
Nicholas Ave. No. 2	Stolons	98.0		0.5	0.5	15	0 5	4.1
Highland.....	Seed	99.5		3	0.5	10	2	3.9
Highland.....	Stolons	99.5		1	2	10	2	3.7
Kernwood ...	Seed	99.5		4	2	5	2	3.2
B.P.I. 14276...	Seed	99.5		3	1	7	1	3.0
Nichols Ave. No. 1	Stolons	99.0		0.5	0.5	10	0.5	2.9
Wykagyl......	Stolons	99.0		0.5	0.5	10	0.5	2.9
Prince Edward Island.... .	Seed	20.0		0	0.5	1	1	0.6
Valentine No. 2	Stolons	99.0		0.5	0.5	0.5	0.5	0.5
Elizabeth. ...	Stolons	90.0		0.5	0	0.5	0.5	0.4
B.P.I. 14276 ..	Stolons	97.0		0	0	0.5	0.5	0.2
	1932							
Yorkshire.....	Seed	99.5		0.5	2	4	3	2.4
Average of all varieties...				4.8	4.1	9.4	2.7	
Average of all but Kernwood* and Yorkshire* varieties........				2.3	1.1	6.5	1.4	

*Used for the main test, 1932.
†Used for the later test, 1932.

pure velvet bent in 1931 and 1932 are shown as well as the monthly change in severity during 1932 from July to October.

It may be seen from Table 1 that varieties such as Kernwood and Highland planted in 1928, Acme of 1929, and Yorkshire of 1930 were more heavily damaged both during the seasons of 1931 and 1932, than

other varieties planted the same year. The varieties B. P. I. 14276 and Mountain Ridge were similarly less heavily damaged during both seasons. These are relatively pure velvet bents. When the varieties which are somewhat mixed with colonial bent such as Newport and German bent of 1928, Oregon-grown seed of 1930, or Prince Edward Island of 1931 are compared with pure velvet bent they are found to have been less damaged in both seasons than the relatively pure turf. The same point is brought out by a comparison of Newport (seed) of 1928 and Newport (stolons) of 1930. It will be noticed that the varieties planted in 1931 were as a rule less damaged during 1932 than those planted during the years previously. The average percentage of damage for all varieties except Kernwood of 1928 and Yorkshire of 1930 indicates rather clearly that the infestation of webworms was the greatest in July and September and that the September attack was the most damaging. Two of the varieties which were seriously damaged in 1931 were selected for use in the test of the insecticides mentioned previously. These were the velvet bents, Yorkshire of 1930 and Kernwood of 1928.

The Yorkshire variety originated in the county of the same name in England It is an extremely fine, vivid light green and upright variety but seems poorly adapted to warm weather. The brown patch preventative treatment used during the past two years has benefited the Yorkshire much more than the Kernwood variety. Kernwood velvet bent originated from a plant found growing on the Kernwood Country Club, Salem, Massachusetts. It has a bright, medium green color, upright habit, and above average fineness of leaf. The Kernwood variety is well adapted to the climate of this region and for that reason is probably the better grass for a test of insecticides. Both varieties have been mildly attacked by large and small brown patch.

Method of Test, 1932.—Both varieties are planted in 20 foot plats, allowing each to be divided into sixteen 5-foot by 5-foot subplats. Since the damage from webworms was rather evident before the treatments were applied, an estimate was made of this damage for each subplat. The 32 subplats available permitted four subplats each for the seven treatments and for four subplats left untreated. In other words each of the seven materials was tested four times, twice on Yorkshire and twice on Kernwood. All of the materials were applied August 6th and October 10th. On October 10, arsenate of lead, 4 pounds per 1000 square feet, was substituted for Paris green because the latter was found to kill out patches of the Yorkshire turf. The per cent of area damaged by webworms in each subplat was estimated again on August 30, September 30, and October 28.

Methods of application, rate of application, source, and cost of the materials for treating 1000 square feet of turf are as follows:

1. Arsenate of lead. This was used as a spray at two rates: (1) ½ pound, and (2) 2 pounds in 20 gallons of water. The cost is approximately 7 cents and 30 cents, respectively, for material per treatment.

2. Paris green A spray was made with ½ pound of the powder in 20 gallons of water As mentioned previously this was found to injure the turf. The cost is approximately 30 cents for materials per treatment.

3. Trade material A is a trade-marked remedy for brown patch and soil insects It was sprayed on at 1/3 pound in 20 gallons of water and the cost is approximately 67 cents for materials per treatment.

4. Pyrethrum No 1 and Pyrethrum No. 2 are trade products usually available locally In this test each was diluted at the rate of 1½ pints per 111 gallons of water and applied with a sprinkling can Dissolved soap was used with the Pyrethrum No 2 The cost of materials of each is approximately $4.00 per treatment

5 Kerosene emulsion. The stock solution consisted of 1 pound of laundry soap, 1 gallon of boiling water, and 1/2 gallon of kerosene The kerosene was gradually beaten into the hot soap solution This stock solution was diluted at the rate of 2 1/5 gallons per 111 gallons of water and applied with a sprinkling can The cost of materials is approximately 20 cents per treatment

RESULTS.—In Table 2 are given the treatments which were applied on August 6 and October 10, the estimate of damage on August 6 before the materials were applied, and the average of the estimates of August 30 and October 28. The estimate of September 30 was found to be of little value since nearly two months had elapsed since the treatment on August 6 It will be seen from Table 2 that the damage on August 6 was not uniform among the subplats devoted to the various treatments For this reason the average of the estimates of August 30 and October 28 was divided by the estimate of August 6 to obtain the corrected average estimate. This was obtained both for brown patch treated and untreated subplats In the next column corrected averages for the treated and untreated subplats are averaged The same tabulations are given for each variety of grass. At the extreme right is given the corrected average damage of the four subplats of the same treatment.

Considering the data in Table 2 for the Yorkshire variety it may be seen that approximately twice the damage occurred on the subplats which were not treated for brown patch as compared with the subplats which were given this mercury treatment. The ⅓ bichloride, ⅔ calomel treatment was used as recommended by the U. S. Golf Association.

It may be seen that the corrected average damage on both the treated and untreated was the least when sprayed with arsenate of lead (2 pounds) or material A, and greatest when no treatment was given. It is also evident that the better treatments on the Yorkshire are also the better ones on the Kernwood variety.

TABLE 2. THE RESULTS OBTAINED WITH VARIOUS TREATMENTS FOR CONTROL OF BLUEGRASS WEBWORMS IN VELVET BENT PUTTING GREEN TURF. THE AVERAGE OF THE PERCENTAGE DAMAGE OF AUGUST 30 AND OCTOBER 28 WAS DIVIDED BY THE PER CENT DAMAGE OF AUGUST 6 BEFORE TREATMENTS WERE APPLIED IN ORDER TO OBTAIN THE CORRECTED AVERAGE DAMAGE

Treatment	Estimates of damage before and after treatment Plat 17—Yorkshire (1930)							
	Aug. 6		Average Aug. 30 and Oct. 28		Corrected Aug. 30 and Oct. 28		Corrected aver. T and Unt.	Corrected average for all subplats
	T	Unt	T	Unt	T	Unt.		
Arsenate of lead, 2 lbs	20	20	6	16.5	30	55	42	24
Paris green	25	30	6.5	24	26	80	53	35
Trade Material A	15	30	5	19.5	33	65	44	37
Pyrethrum No. 1	20	25	4 7	21.5	24	86	52	43
Pyrethrum No. 2	15	30	7.5	31.5	50	105	72	57
Arsenate of lead, ½ lbs		30		27.5		92	79	74
No treatment	20		15		75		82	86
	20		18		90			
Kerosene emulsion	20	30	10.5	31.5	52	105	79	103
Average .					48	82		
	Kernwood (1928)							
Arsenate of lead, 2 lbs	10	10	.5	.5	5	5	5	24
Paris green	10	15	2.2	1.7	22	12	17	35
Trade Material A	10	10	5	1	50	10	30	37
PyrethrumNo. 1	10	5	5.2	.7	52	15	33	43
Pyrethrum No. 2	12	12	8.5	1.7	71	13	42	57
Arsenate of lead, ½ lbs	7	10	8.7	1.2	125	12	69	74
No treatment	7	10	3	13.5	43	135	89	86
Kerosene emulsion . .	10	10	10	15.2	100	152	126	103
Average . . .					58	58		

T = Brown patch treatment.
Unt. = No brown patch treatment.

The most satisfactory indication in the table is the similarity between the rank of the materials obtained as the average of all the subplats and the rank on the Kernwood variety. Arsenate of lead applied at the rate of 2 pounds per 1000 square feet has given considerably the best control on the Kernwood and was the best in the averages of each of the varieties. Material A and pyrethrum No. 1 were found to be about equally effective on the Kernwood and when all plats were averaged. Pyrethrum No. 2 seemed to give somewhat less control than pyrethrum No. 1. Only a very slight effect on the webworms resulted from the use of arsenate of lead, ½ pound. The kerosene emulsion was least effective of all treatments.

PRELIMINARY TEST OF ANOTHER TRADE PRODUCT.—Another test was begun on October 10 as indicated in Table 3. This was placed on the plat of B. P. I. 14276 velvet bent planted in 1929. This plat lies between the Yorkshire and Kernwood plats which were used in the test described above. There were 16 subplats and 3 treatments, rotenone, pyrethrum No. 1, and arsenate of lead, 2 pounds. The former is a trade extract of rotenone which is both a stomach and contact poison. A note was taken on October 28 of the per cent of area damaged and the last column of the table (3) gives the average damage for the four subplats.

The test merely indicates that some control was obtained with all materials tried and that arsenate of lead may be fully as effective as either rotenone or pyrethrum No. 1 as applied in this test.

TABLE 3. RESULTS OF A TEST OF MATERIALS APPLIED ON OCTOBER 10 FOR CONTROL OF BLUEGRASS WEBWORMS. THE TABLE GIVES THE NUMBERS OF THE SUBPLATS WHICH RECEIVED PARTICULAR TREATMENTS, THE RATE OF APPLICATION OF THE INSECTICIDES, THE PERCENTAGE DAMAGE ON OCTOBER 28 AND THE AVERAGE OF THE DAMAGE ON THE FOUR SUBPLATS

Subplats	Treatments	Per cent damage Oct. 28	Average
1-7-9-15	Check—no treatment..	0-0-1-8	2.25
2-8-10-16	Rotenone—1½ pints per 111 gals. water per 1000 square feet. Cost—approximately the same as pyrethrums . .	0-0-0-1	.25
3-5-11-13	Pyrethrum No. 1—same as for rotenone	0-0-2-0	.50
4-6-12-14	Arsenate of lead—2 lbs. in 20 gals. water per 1000 square feet...	0-0-0-0	00

The results of both experiments indicate that arsenate of lead, (2 pounds) was the most effective treatment for webworms under the conditions which prevailed during the past season. Since arsenate of lead is commonly used in the control of grubs, earthworms, and mouse-ear chickweed it could be applied as a spray for the control of webworms with little additional expense. Paris green was effective on the webworms but injured the turf severely. A rather high rank among the insecticides was won by material A. A moderate control was obtained with pyrethrum No. 1 and somewhat less with pyrethrum No. 2. Arsenate of lead (½ pound) was only slightly effective.

SUMMARY.—Damage from the bluegrass webworm in demonstration plats of velvet bent during 1930 and 1931 was rather serious. A test was begun in August, 1932, of various promising insecticides. Two doses were applied on two varieties of velvet bent. The results indicate the following ranking as to effectiveness at the rates given per 1000 square feet:

1. Arsenate of lead, 2 pounds in 20 gallons of water sprayed into the turf. Pressure was maintained at approximately 50 pounds.

2. Paris green, ½ pound diluted and applied as No. 1.

3. Material A,—brown patch and soil insecticides—⅓ pound in 20 gallons water as a spray.

4. Pyrethrum No. 1,—pyrethrum extract applied with a sprinkling can at the rate of 1½ pints in 111 gallons of water.

5. Pyrethrum No. 2,—pyrethrum spray applied with a sprinkling can at the same rate as No. 4.

6. Arsenate of lead at ½ pound in 20 gallons of water as a spray.

7. No treatment or check plats

8. Kerosene emulsion applied at the rate of 2 1/5 gallons of stock solution in 111 gallons of water and applied with a sprinkling can

A similar test was begun on October 10 of rotenone, pyrethrum No 1, and arsenate of lead (2 pounds) for webworm control. In this test arsenate of lead (2 pounds) was fully as effective as the other treatments.

IRREGULARITY AMONG COTTON PLANTS IN TIME OF FRUITING AS A FACTOR AFFECTING SUSCEPTIBILITY TO DAMAGE BY THE COTTON BOLL WEEVIL

By P. W. Calhoun, *Gainesville, Fla.*

Abstract

Considerable irregularity seems to exist among cotton plants as regards earliness of fruiting. Using the time of appearance of the first blossom on each plant as the criterion, the frequency distribution for 600 plants approximated a normal curve, the maximum for the frequency histogram occurring on the 11th day It is suggested that such lack of uniformity in time of fruiting perhaps contributes to increased susceptibility of cotton to damage by the boll weevil (*Anthonomus grandis* Boh).

The peculiar shape of some rate-of-blossoming curves, in which the number of blossoms per day was determined by mass counts, suggested to the writer that perhaps considerable irregularity might exist among cotton plants as to the time each plant begins to fruit. One such curve suggested rather strongly that a small percentage of the plants were much earlier bloomers than the majority of the plants of that group. These few early plants apparently—judging solely from the shape of the blossom curve—also ceased to blossom earlier than the majority of the plants. In other words, in this case at least, considerable lack of coordination seemed to exist among the different plants as to the time each produced its crop.

Such a condition would obviously contribute to greater susceptibility to damage by the boll weevil, for the few early plants would serve as

early breeding places for weevils which would migrate to the later plants before the bolls on the latter had matured. Under some conditions it would appear possible for a few very early plants to do considerable damage in this manner.

In view of the above, it seemed desirable to determine approximately the degree of irregularity which exists in the time of fruiting of the different cotton plants. Six blocks of 100 plants each of upland cotton were staked off, and the date on which each plant produced its first

TABLE 1. AVERAGE PER CENT OF PLANTS WHICH BEGAN BLOOMING ON SIX BLOCKS OF 100 PLANTS EACH OF UPLAND COTTON AT GAINESVILLE, FLA., 1930

Number of count	Average per cent beginning to blossom on count indicated* Daily	Total	Number of count	Average per cent beginning to blossom on count indicated* Daily	Total
1	1.5	1.5	14	1.8	56.9
2	1.7	3.2	15	5.7	62.6
3	2.0	5.2	16	5.7	68.3
4	3.7	8.9	17	6.7	75.0
5	2.8	11.7	18	3.8	78.8
6	4.5	16.2	19	2.3	81.1
7	4.3	20.5	20	2.2	83.3
8	4.7	25.2	21	1.8	85.1
9	5.5	30.7	22	2.7	87.8
10	6.3	37.0	23	2.0	89.8
11	7.8	44.8	24	2.5	92.3
12	7.3	52.1	25	1.0	93.3
13	3.0	55.1	26	1.3	94.6

Weighted average for 26 counts, 12.6.

*The percentages given in this column represent one-sixth of the sum of the percentages which blossomed on each block on the corresponding count. The recorded counts for each block were begun upon the appearance of the first blossom on that block.

blossom was recorded. From these data the rate-of-beginning-to-blossom was calculated for each block of 100 plants—the rate being calculated as the percentage of plants which produced their first blossom on each count. The recorded counts were begun on each block on the day the first blossom appeared on that block.

The rates-of-beginning-to-blossom for the six blocks were then averaged by adding the percentage of plants which had produced their first blossom on each count and dividing by six. Table 1 and Fig. 103 show these data in tabular and graphic form respectively.

It is apparent from Table 1 and figure 103 that considerable irregularity in earliness of fruiting did exist among the plants. The very earliest plants blossomed about 12 days earlier than the last half. While it is true that the first half of the plants to blossom would, in the entire absence of boll weevils, produce more cotton than the last half to blossom, nevertheless a large part of the plants which did produce an average

number of bolls began to fruit nine or ten days later than the earliest ten per cent Had a heavy infestation of boll weevils been in the field, it seems plausible that the presence of the very early plants would have reduced the crop rather than increased it, by increasing the weevil damage on the much more numerous plants of only average earliness

Comparison of the frequency histogram with the normal curve of best fit shows that the variation in earliness of beginning to fruit approximated a normal distribution

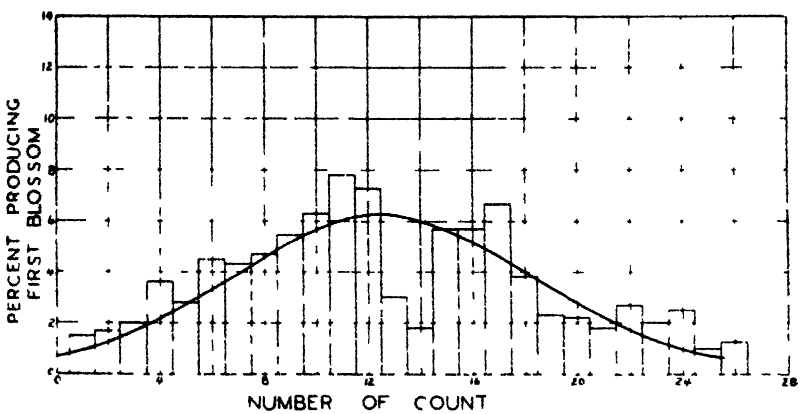

Fig. 103.—Frequency histogram based on data of Table 1, with normal distribution curve of best fit.

No especial effort was made to select conditions which would tend to reduce to a minimum the irregularity in time of fruiting The spacing in some of the blocks was wider than in others Most of them, however, were spaced from 8 to 12 inches in the drill, with from one to two plants per hill. The variety used, in all but one block, was a strain of Lightning Express which has been a consistent high yielder at Gainesville All blocks were fertilized with 400 lbs of 8-4-4 at planting time and all received an application of soda at chopping time

A poor stand was secured in two blocks, and these had the skips filled in by later plantings with a hoe These two blocks showed some, but not a great deal, more variation in time of beginning to blossom among the different plants than the other blocks One block was planted considerably later than the others. There was less variation in time of beginning to blossom in this block than in the others. However, none of the blocks varied greatly from the mean of the group, and most of them were very close to the mean. Conditions were such that the writer

would expect the variations observed to be very comparable to those which would be found under high-grade general farming practice.

In the procedure used for making Table 1 it should be noted that the starting date for each block is considered the same, in spite of the fact that actually some of the blocks began to blossom a week or more earlier than the others, due to differences in soil types, spacing, etc. In a sense this reduces somewhat the apparent irregularity among the plants in time of beginning to blossom for the group of six hundred plants, since, according to the procedure used, each plant is compared only with the plants near it. However, this seems desirable when the irregularity in time of beginning to blossom is being studied with regard to its effect on the susceptibility of cotton to damage by the boll weevil, since most of the weevils that breed on the early plants during the early part of the season migrate only to plants in the immediate vicinity.

No attempt was made to study the causes of the variation among the plants in time of beginning to fruit. Environmental conditions probably are largely responsible, although very likely it is to a certain extent a varietal characteristic

THE NUMBER OF LARVAL INSTARS AND THE APPROXIMATE LENGTH OF THE LARVAL STADIA OF *DENDROCTONUS PSEUDOTSUGAE* HOPK., WITH A METHOD FOR THEIR DETERMINATION IN RELATION TO OTHER BARK BEETLES

By W. D Bedard, *Assistant Entomologist, United States Bureau of Entomology, Forest Insect Field Station, Coeur d'Alene, Idaho*

Abstract

Investigators encounter considerable difficulty in studying the development and habits of larvae which mine beneath the bark of trees. A method is here outlined whereby such a study can be accomplished, and its application is demonstrated in the case of the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.). The usefulness of this information in a thorough study of larval parasites and its value in the economic control of the Douglas-fir beetle are shown.

Past investigative studies of bark beetles have given but scant attention to larval development, because the economic value of such detailed information was not then apparent. Control measures were developed and put into practice with little or no consideration for the biological control factors involved. As a result, most of the controls now in use, though successful in destroying the pest, are perhaps equally destructive to the beneficial parasitic and predacious insects as well.

With a greater realization of the economic value of these biological agents, studies have been instituted with the object of timing present methods of control so that full advantage can be taken of the natural enemies of the pest. The purpose of this paper is to show how a more thorough knowledge of larval development may contribute towards a solution of our problems of bark-beetle control, and to outline a method which was found to be of considerable aid in studying the larval habits of the Douglas-fir beetle.

Following the entrance of bark beetles into the new hosts, there is a well defined lapse of time before the resulting broods are attacked by parasites and some of the predators. If it were possible to direct control measures against the bark beetles only during this period, the beneficial insects would be saved, and thus the control would be far more effective. In determining the length of time available for the application of such favorable control before the appearance of any particular parasite for which protection is desired, it is necessary to ascertain which larval instar of the host is preferred by the parasite, and when this stage of development is reached by the bark-beetle larvae. To accomplish this, it is obviously necessary to have a thorough knowledge of the larval development of the host larvae.

Furthermore, a knowledge of larval habits is required for the successful colonization of a parasite in a new locality, because the adult parasites must be liberated at a time when the host is in the proper stage to be parasitized; i. e., when the preferred instar is available in suitable numbers.

Finally, a knowledge of larval development might contribute in a number of ways to the scanty information now available regarding bark-beetle fluctuations. For example, it might be found that one instar consistently showed a high mortality rate and that conditions preceding an epidemic had been optimum for the bark beetle during the duration of this instar, with the result that a large percentage of the brood had lived through this critical period. In such a case the increase would be sufficient to disturb seriously the natural balance and result in a rapid building up in the numbers of the pest. In addition, such a study might demonstrate a lack of synchronization between the seasonal histories of parasite and host which would cause a decrease in the abundance of the parasite with a subsequent increase in the numbers of the beetle.

The importance of possessing these data became apparent in a study of the braconid *Coeloides brunneri* Vier., which is the most important larval parasite of the Douglas-fir beetle. The study was carried on in connection with an investigation of this beetle.

These Dendroctonus larvae mine in the phloem of the host tree, and consequently extreme difficulty arises in making daily observations for the purpose of counting the number of molts and recording the time which elapses between the consecutive ecdyses Several rearing devices

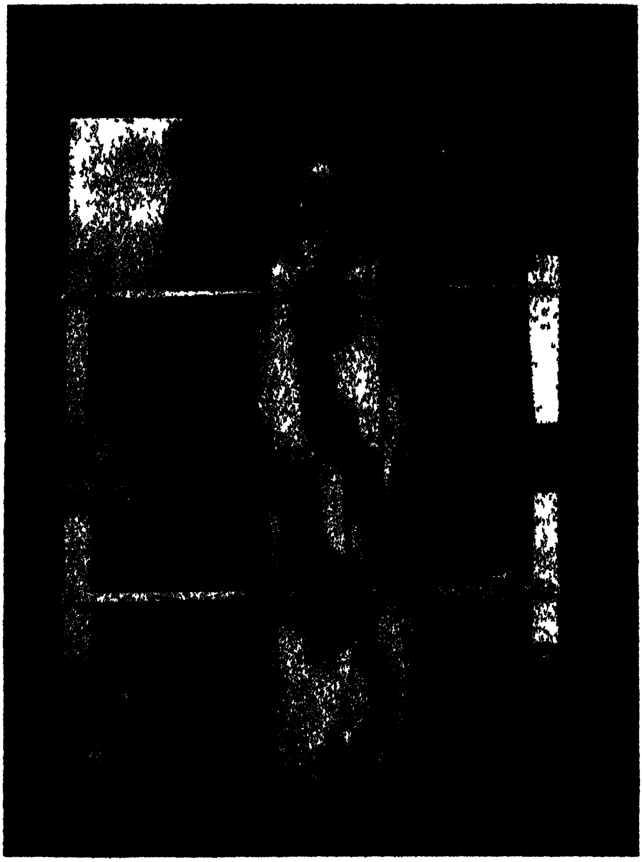

FIG. 104.—One of the glass-plate rearing devices used in this study. (Photograph by H. J. Rust.)

were tested to accomplish this purpose, but, with one exception, they were not successful Fair results were obtained by allowing adult female beetles to construct galleries in a thin sheet of inner bark, held between two plates of ordinary window glass. (Fig 104.) The bark was pared to such thinness that the beetles were allowed just sufficient room to work between the two glass plates yet were kept visible at all times. Although not shown in the illustration, it was found necessary to pack cotton

around the bark between the two plates and moisten the cotton daily in order to prevent excessive drying of the bark. The entire device was then wrapped in a black cloth to exclude light and thus make conditions more natural for the insect. Successful incubation of eggs was obtained in this apparatus, and the resultant larvae could be observed daily in the tunnels until, during the second stadium, they passed out of sight into the host material. By transferring the larvae to a thinner piece of material it was hoped to prevent this disappearance, but the needed reduction in thickness caused rapid drying of the bark with subsequent larval mortality.

Unfortunately, there is no anatomical character whereby the various instars can be distinguished from one another and, as the size of the body

TABLE 1 COMPARISON OF THEORETICAL AND ACTUAL DIMENSIONS OF HEAD CAPSULES OF LARVAE OF THE DOUGLAS FIR BEETLE

Dimension	Instar	Theoretical measurement *Mm*	Actual measurements Mean *Mm*	Standard deviation *Mm*	Min. *Mm*	Max. *Mm*	Individuals measured *Number*
	1	*0.454	0.462	0.031	0.428	0.523	200
	2	* .583	.552	.0197	.500	.600	200
Length	3	.746	.734	.0327	.650	.800	200
	4	.955	.919	.0547	.785	1.025	200
	5	*1.21	1.24	.0788	1.125	1.375	200
	1	* 507	.523	.024	.476	.585	200
	2	* .644	.615	.0126	.585	.685	200
Width	3	.824	.791	.0478	.700	.850	200
	4	1.05	1.03	.0803	.900	1.20	200
	5	*1.34	1.38	.0766	1.238	1.50	200
	1	* .270	.278	.0475	.230	.385	200
	2	* .347	.365	.0217	.350	.400	200
Width of frons	3	.444	.482	.030	.400	.550	200
	4	.568	.618	.0479	.500	.700	200
	5	* .727	.811	.0455	666	.900	200

*Mean of actual measurements of 50 head capsules.

is so variable, the head-capsule dimensions are the only criteria for identification. It was possible, however, by this type of rearing, to secure head capsules from two successive ecdyses, namely, those of the first and second instars. With measurements made of these, and the aid of Dyar's Law,[1] which is applicable also to these beetles, a series of figures can be calculated which represent the head-capsule dimensions for any number of ecdyses which may follow the two already known. In order to terminate this series properly, head capsules from last larval

[1]Dyar, H. G. 1890. The number of molts of lepidopterous larvae. Psyche 5: 420–422.

instars can be collected from pupal cells and measured to determine which of the calculated figures is that of the last instar.

In the case of *Dendroctonus pseudotsugae*, 50 head capsules each of the first, second, and last instars were secured and measured. In addition

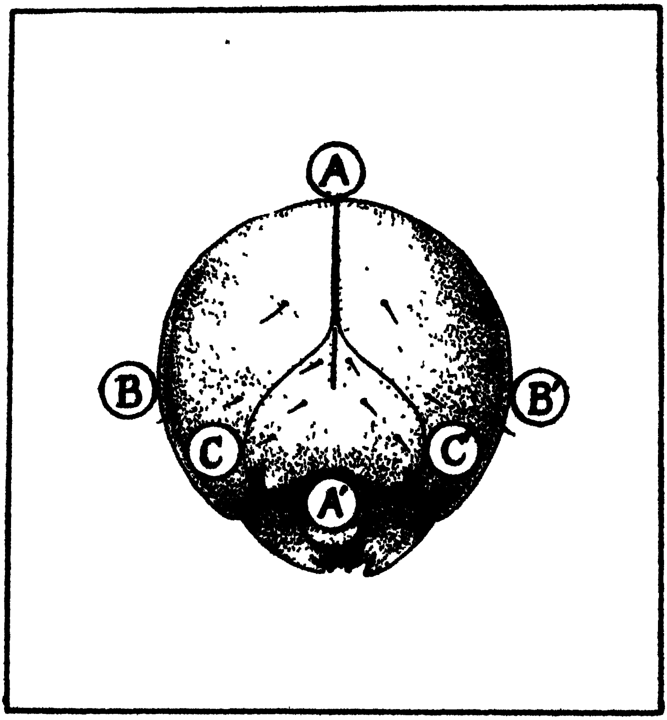

FIG. 105 —Head capsule of *D. pseudotsugae* larva, showing measurements taken. A-A[1] length B-B[1] width. C-C[1] width of frons

to the usual measurements of length and width, a third measurement, the width of the frons, was taken. (Fig. 105.) This additional dimension was used because the head capsules found attached or adjacent to the Coeloides hibernacula are usually broken, and very often the width of the frons is the only measurement obtainable. Table 1 gives a comparison of the head-capsule dimensions, as obtained by the above method, with the average dimensions secured by actual measurement of 200 entire head capsules from each instar.

Table 1 shows that the theoretical dimensions for the first, second, and last instars check very closely with those obtained by the actual measurement of a large number of additional head-capsules and that

the material is well centered within the range. Because these dimensions checked so closely and because all head-capsules not of the first, second, or fifth instars fell definitely into two groups, the author felt justified in calling these the third and fourth instars and checking them against the theoretical dimensions. It will be noted that there is some overlapping between the sizes of the head-capsules of the various instars. However, when a doubtful case occurs with one measurement, it has been found that one or both of the other two measurements will show to what instar the head-capsule belongs.

Having thus established the number of instars of the host larva, it was desired to determine the approximate duration of each stadium. Taylor[2] describes a method for so doing when the larvae to be studied are hidden in the host material, as are the cambium miners and leaf miners. Briefly, this is done by collecting a number of the larvae each day and recording the instars collected under the date of collection. Then the length of each stadium can be calculated by counting the number of days from the first appearance of one instar to the first appearance of the next instar and the number of days between the last dates of appearance of the same two instars, adding these two numbers together, and dividing their sum by 2

TABLE 2 RANGE OF OCCURRENCE OF THE VARIOUS INSTARS OF THE DOUGLAS-FIR BEETLE AND THE CALCULATED LENGTH OF THE STADIA

Instar	First occurrence	Interval till first occurrence of next stadium *Days*	Last occurrence	Interval till last finding of next stadium *Days*	Average duration of stadium *Days*
Instar 1	June 9	6	July 15	6	6
Instar 2	June 15	15	July 21	11	13
Instar 3	June 30	14	Aug. 1	18	16
Instar 4	July 14	13	Aug. 19	19	16
Instar 5	July 27	18	Sept. 7	16	17
Pupa	Aug. 14	—	Sept. 23	—	—

In the application of this method, approximately 50 Douglas-fir beetle larvae were collected daily from a regular route which comprised 10 trees, 2 of which were windfalls. These trees represented varying conditions of bark thickness and exposure to the sun, and at each collection larvae were taken from all four sides of the tree. This diversified material was selected because of the effect which temperature and humidity exert upon the development of bark-beetle larvae. Table 2 shows the incidence of the various instars as found by these collections

[2]Taylor, R. L. 1930. A simple statistical method for determining the approximate duration of the instars of leaf-mining larvae and others. Journal of Economic Entomology 23: 587–595.

and the application of Taylor's method for the determination of the lengths of the various stadia.

Thus the approximate durations of the various stadia, from the first instar to the fifth, are 6, 13, 16, 16, and 17 days, respectively. These stadium lengths, although only approximate, are nevertheless quite applicable for the purposes already pointed out. For example, head-capsules of parasitized Douglas-fir beetle larvae are found clinging to the Coeloides hibernacula. Two hundred of these capsules were collected and measured, and it was found that only the fourth instar and a few fifth-instar larvae had been parasitized. By consulting Table 2, it can be seen that fourth-instar larvae do not appear until about the middle of July. Attacks by this beetle begin early in May and the parasite emerges approximately two months later in order that the preferred larval instar of the host will be present in the newly attacked trees when oviposition begins. The control methods used at present comprise the decking and burning of the infested logs in the fall of the year, thus destroying the parasite as well as the beetle. However, control operations using the decking and burning method can be instituted about the first of June and continued until the middle of July without any destruction of the parasite. It is not definitely recommended, however, that control be done in the spring in preference to the fall, because in some areas the method would prove to be a great fire risk which would prohibit its use; although the work could be done successfully in other areas. Furthermore, it is not known whether the advantage secured in preserving the parasite will compensate for the numerical increase of the bark beetle if fall control is omitted and the beetles are allowed to perpetrate the spring attack before control is undertaken. These problems must be solved before the actual recommendation of spring control, but analyses of data indicate that the change may prove to be a feasible one.

In conclusion, it might not be amiss to remark that the duration of the various stadia, as given in this paper, can not be taken as standard throughout the range of the insect. Climatic factors exert such a strong influence upon insect development that, of necessity, the investigation must be conducted in the locality where the data obtained from the study are to be applied.

THE RESISTANCE OF LEAVES OF RED CLOVER TO PUNCTURING[1]

By H. H. Jewett, *Kentucky Agricultural Experiment Station*

Abstract

Leaves of a Kentucky red clover, No. 101, and an Italian red clover were tested as to resistance to needle puncturing. It was found from puncturing 500 leaves of each clover that the Kentucky clover offered greater resistance to puncturing than the Italian clover. The Kentucky clover is more resistant to leafhopper injury than the Italian clover Since the insect feeds by puncturing plant tissue, it is thought that this greater resistance to leafhopper injury is due, in part at least, to greater resistance to puncturing.

A study of injury to red clover by the leafhopper, *Empoasca fabae*, has shown that while clovers with rough hairy pubescence are injured less than those with appressed pubescence or without pubescence, not all hairy strains are equally resistant Clovers with practically the same number of hairs differed considerably as to their ability to resist hopper injury. This was shown by a series of tests made in 1932.[2]

Since this insect gets its food by piercing the tissues with its beak, it was thought that some kinds of clover may be more easily punctured than others In order to measure resistance to puncturing, an instrument with a very fine needle was made for the purpose. A Kentucky and an Italian red clover were selected for the tests and 500 leaves of each kind were punctured.

Method of Procedure.—The clovers used in the tests were grown in pots in the greenhouse. They were the same age and were grown under the same conditions of moisture, lighting and temperature The plants were small and were graded as nearly as possible as to size and condition of growth.

All leaves of the plants selected for the tests were punctured. The punctures were made in the central portion of each leaf and several trials were generally required before a satisfactory reading could be taken. The weight necessary to force the needle through the leaf varied for different leaves on the same plant and for different plants.

The apparatus used for puncturing the leaves is illustrated in Fig. 106. The bar at the right side of the pivot is marked with a millimeter scale. The pressure which the bob (A) exerts upon the needle was determined

[1]The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

[2]Kentucky Agricultural Experiment Station, Bulletin 329. The Resistance of Certain Red Clovers and Alfalfas to Leafhopper Injury.

for each scale division, and tabulated The table or rest (B) for supporting the object has a small opening for the passage of the needle This table was kept at the same elevation while the readings were being taken The lever (C) could raise or lower the needle

To operate the instrument, a leaf is placed on the object-table, the needle is lowered till contact with the leaf is made and the weight bob is shifted to a position where the needle punctures the leaf A glance at the table shows the correct weight necessary to make the puncture.

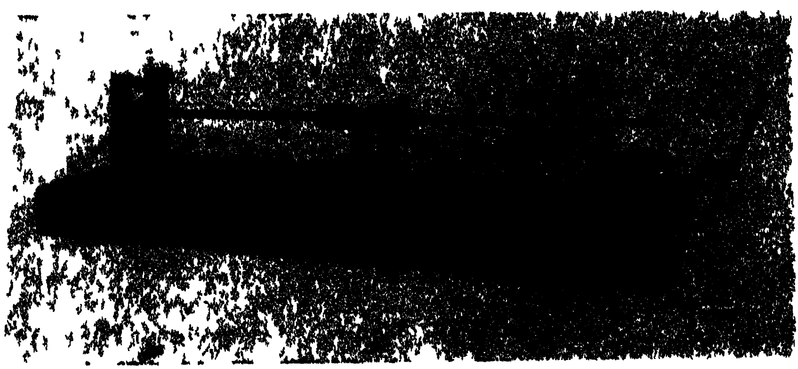

FIG 106 —Apparatus for puncturing the clover leaves

RESULTS OF THE TESTS —The weights, in grams, necessary to force the needle through the leaves of the clovers all come within the range of 1.50 to 3 79 The weights for each clover were arranged in a table and the mean, and standard deviation were determined for each The standard error of the difference of the two means was then determined The mean for the Kentucky clover was 2 777 grams, with a standard deviation .3943 The mean for the Italian clover was 2 662 grams with a standard deviation 3845 The actual difference between the two means was 115 grams The standard error of the difference of the two means was 0246

The difference between the two means is over 4 6 times the standard error of the difference of the two means It is customary to take a difference of three times the standard error as indication of complete reliability, since—3σ includes practically all of the cases in the "distribution of differences" below the mean. Under the Normal Probability Curve (P 91, Table 10, Statistics in Psychology and Education by Garrett) we find that 9999 932 cases in 10,000 or 99.999 per cent of the distribution fall within the limits set by -4.5σ and $+4.5\sigma$ (by cutting off the curve at these two points only .001 of 1 per cent is disregarded).

It is clear that the chances are 9999.932 in 10,000 that the true differences between the averages of the Kentucky weights and the Italian weights is greater than zero. We may be certain, therefore, that there is a true difference between the average weights in favor of the Kentucky clover and that the average Kentucky red clover leaf is more difficult to puncture than the average Italian red clover leaf.

Since leaves of the Kentucky clover offer greater resistance to needle-puncturing than leaves of the Italian clover, it is reasonable to assume that they offer greater resistance to puncturing by the leafhopper.

FRUIT INJURY ON APPLES FOLLOWING NICOTINE TANNATE SPRAYS*

By Byrley F. Driggers, *Associate Entomologist, New Jersey Agricultural Experiment Station.*

ABSTRACT

A peculiar type of fruit injury following the use of nicotine tannate on apples was not duplicated when three varieties of apples were sprayed with nicotine tannate four times during July and August. Observations indicate that the injury occurs when the fruit is young and relatively easily injured. Evidence points to the presence of tannic acid as being responsible for the injury and that an excess of free nicotine in the early cover sprays will reduce the amount of injury.

During the summer of 1932 the Department of Entomology of the New Jersey Agricultural Experiment Station conducted a series of experiments to control codling moth in a heavily infested orchard near Glassboro. A number of materials were tested including (1) the standard lead arsenate treatment, (2) summer oil emulsion and lead arsenate and (3) nicotine tannate. The details concerning the amount of materials used, dates of application and the comparative performance of the different spray mixtures have been reported elsewhere.[1] In general it might be stated that the materials were applied as cover sprays three times during the month of June and four times during July and August to protect the fruit from the first and second broods of codling moth larvae. A mid-season variety (Wealthy) and several late-season varieties (Stayman and Winesap) were included in each block sprayed with the different mixtures.

A peculiar type of injury on the fruit was observed about the first of July on the block sprayed with nicotine tannate. The injury appeared

*Paper of the Journal Series, New Jersey Agricultural Experiment Station. Department of Entomology.

[1]Headlee, Thomas J. Transactions of Peninsula Horticultural Society in Bulletin of the State Board of Agriculture, Camden, Delaware, Vol. 22, No. 5.

as corky, dark brown spots about one to two millimeters in diameter. They were usually located on the underside of the apple where the spray residue was concentrated. An examination of the fruit outside of the nicotine tannate block failed to disclose any similar injury where other spray materials were used. The nicotine tannate block was sprayed three times during June with tank mixed nicotine tannate, the first two applications carrying flotation sulfur as a protection against apple scab. The tannic acid used was an amorphous powder obtained from Chinese gall nuts. In preparing the spray, the powdered tannic acid is dissolved in the spray tank with the agitator running while the tank is being filled. Fifty per cent free nicotine is added just before the tank is full. The charge used was two pounds of the tannic acid powder and one pound of the free nicotine to 100 gallons of water Since flotation sulfur and free nicotine have both been used rather extensively without the appearance of this particular injury, suspicion was directed to the tannic acid as the cause. It was suggested that possibly part of the tannic acid failed to dissolve and react with the free nicotine and that this free tannic acid in some manner brought about the injury already described It was also suggested that the tannic acid used in the Glassboro tests may have contained impurities of some kind

In order to get further information on the cause of the injury it was decided to spray additional blocks during July and August with nicotine tannate made from tannic acid obtained from different sources An orchard was selected at Moorestown consisting of four rows each of the varieties Wealthy, Stayman and Rome Beauty The rows averaged 35 trees to a row, making a block of somewhat over 400 trees. This orchard had received four cover sprays for first brood codling moth up to July 11 The first, second and fourth cover sprays consisted of 4 pounds lead arsenate, 9 pounds lime and 1 pound spreader to 100 gallons of water. The third cover spray consisted of 2 pounds lead arsenate, 3 quarts Orthol-K oil and 1 pound spreader to 100 gallons.

Six blocks, each block four rows wide and running across the three varieties, were laid out in the center of the orchard During the period second brood larvae were hatching these six blocks were sprayed at ten-day intervals on July 11th and 20th and on August 1st and 11th. Blocks 1 and 6 were sprayed on July 11th, 21st and August 11th with lead arsenate 2 pounds, Orthol-K oil 3 quarts and 1 pound of spreader to 100 gallons of water. The cover spray of August 1st on these two blocks consisted of 4 pounds lead arsenate and 1 pound of spreader to 100 gallons of water. Block 2 was sprayed with nicotine tannate, the tannic acid used being an amorphus powder supplied by the Taylor-White Com-

pany of Camden, New Jersey. Block 3 was sprayed with nicotine tannate, using another sample of tannic acid in the form of an amorphus powder Block 4 was sprayed with nicotine tannate using a liquid tannic acid solution containing 50% tannic acid. Block 5 was sprayed with nicotine tannate also and the tannic acid used was ground Chinese gall nuts The tannic acid used in blocks 3, 4 and 5 was supplied by Zinsser and Company, Hastings-on-Hudson, New York.

The fruit in the different blocks was examined frequently from mid-July to harvest to determine whether the injury appeared which had been observed earlier at Glassboro. An injury somewhat similar to that which appeared early in the season was observed on two trees (Rome Beauty). Since one of these two was located in block 6 which received no nicotine tannate, it appears that this particular injury was not due to any combination of nicotine and tannic acid These tests served to show that the particular injury under consideration is less likely to develop when nicotine tannate is applied from mid-season on.

Orchard block tests for codling moth control were run at Glassboro during the season of 1933 on the Stayman variety. One block received nicotine tannate as the insecticide in all cover sprays This block was sprayed with lead arsenate and commercial lime sulfur at the calyx spray. The first cover spray was applied seven days later and carried nicotine tannate and flotation sulfur. An extra pint of free nicotine was added to each 100 gallons of the nicotine tannate-flotation sulfur to combat aphids Additional cover sprays of nicotine tannate and bentonite-sulfur were applied at ten day intervals during first brood on this block. About the time the fourth cover spray was applied a few apples were observed which showed the typical injury Less than one-half of one per cent of the apples in the block were thus affected, therefore, commercially, the injury was negligible.

Certain observations indicate that the injury occurred shortly after the fruit was formed and during the period nicotine tannate was applied at the first and second cover sprays For example, one tree in the nicotine tannate block was left unsprayed after the first cover spray. (It will be recalled that the first cover spray carried nicotine tannate and flotation sulfur.) Injury on the fruit on this tree was just as pronounced as it was on surrounding trees which received some 8 or 10 additional cover sprays of nicotine tannate If uncombined tannic acid is responsible in some manner for the injury an explanation for the small amount of injury in the tests this year presents itself. The extra pint of free nicotine used in the first cover spray to combat aphids would tend to tie up any free tannic acid in the tank thus lessening the danger of injury from free tannic acid.

STUDIES OF THE "RESISTANT" CALIFORNIA RED SCALE *AONIDIELLA AURANTII* MASK. IN CALIFORNIA

WILLIAM MOORE[1], *Owl Fumigating Corporation, Azusa, Calif.*

ABSTRACT

A preliminary study of the "resistant" red scale (*Aonidiella aurantii*) of California has been made involving the influence on the kill of the type of hydrocyanic acid concentration, the stage of development of the insect, the temperature of the host, the temperature and relative humidity preceding, during and after the fumigation, and protective stupefaction. It was found that the type of concentration and the percentage of insects in the resistant stages did not determine the effectiveness of the fumigation. Temperature and relative humidity had a decided influence. Protective Stupefaction may or may not be an important factor

In the early work of fumigating citrus trees with hydrocyanic acid, a failure to control the insects was considered due to faulty work or equipment. In 1922, Quayle (9) presented tests to indicate that in certain areas in California, the red scale was actually more difficult to kill than in certain other areas. Woglum (12) related field results showing that with even more than 100% dosages of hydrocyanic acid, satisfactory kills were not obtained in certain areas

The trees in these "resistant areas" are infested with what is generally considered a biological race of the California red scale characterized by its ability to withstand even more than 100% dosages of hydrocyanic acid. "Resistance" is generally encountered in the Corona district, the plantings along the southwest side of the Santa Ana Mountains from Tustin northwest to La Habra and Whittier, on the north and south slopes of the Puente Hills and more recently on the hills north of Glendora westward to Azusa. Ebeling (3) has recently pointed out that the "resistant" red scale is in the areas with least danger of frost. These areas are frequently planted to lemons, hence the "resistant" red scale is associated with lemons more commonly than with oranges.

METHODS OF DETERMINING KILLS.—Ebeling (2) has shown that following a fumigation with hydrocyanic acid the best kills will be found on the wood and leaves and the poorest kills on the fruit. Knight (7) has pointed out that in the case of oil sprays poorer kills were obtained on heavily infested fruits than on the lightly infested fruits. He suggests that the same is true of fumigation results. Ebeling (3) also suggests that population density influences fumigation results.

[1]The writer wishes to express his appreciation of the work of J. A. McDonough Harold Orde, Nelson Howard, Jr., J. R. Alcock and Robt. Wathen in making hundreds of chemical analyses and counting over three and a half million red scales in this work.

Table 1 gives the results of counts made in two fumigated orchards. These counts indicate that the density of the population makes no particular difference in the results of the fumigation.

TABLE 1. THE RELATION BETWEEN DENSITY OF POPULATION AND THE KILL

	La Habra			Glendora		
	Number of lemons	Number of insects	Per cent dead	Number of lemons	Number of insects	Per cent dead
Less 100 per lemon...	104	7,003	99.21	72	4,172	97.63
100–199 per lemon. .	168	24,892	99.73	93	13,727	96.18
200–299 per lemon....	97	23,700	99.87	87	21,217	97.06
300–399 per lemon....	60	22,670	99.64	71	27,714	96.87
400 or more per lemon	38	26,172	99.85	156	78,877	96.78
	467	104,437	99.74	479	145,707	96.87

In the work reported in this paper, lemons with a dense scale population were generally used. Sufficient lemons were used in each set to make a total of 5000 to 20,000 insects. The probable error in the kill was determined, after the natural mortality was deducted, by the formula given by Hartzell (5).

$$\text{Per cent kill} = 100\,p \pm 67.449\sqrt{\frac{\bar{p}\,\bar{q}}{N}}$$

$\bar{p}$ = percentage of dead scale, $\bar{q}$ percentage of live scale, N = total number of insects. In comparing two sets, the observed per cent kill with its probable error determined by the above formula was compared with the expected per cent kill with its probable error determined by the formula

$$100\,\bar{p} \pm 67.449\sqrt{\bar{p}\,\bar{q}\left(\frac{1}{N_2}+\frac{1}{N_1}\right)},$$ N_1 being the number of insects in the standard and N_2 the number of insects in the set being compared with the standard. Either set being compared may be used as the standard.

INFLUENCE OF THE TYPE OF CONCENTRATION ON THE KILL.—There have been many changes in the materials used and their method of application since the beginning of fumigation with hydrocyanic acid in California. An idea persists among fumigators and growers that the results would be better than they are today if old materials and methods were used.

The first hydrocyanic acid was generated in an earthenware jar from potassium cyanide and dilute sulphuric acid. Woglum (10) states that when he came to California, he found the fumigators using from 2 to 8

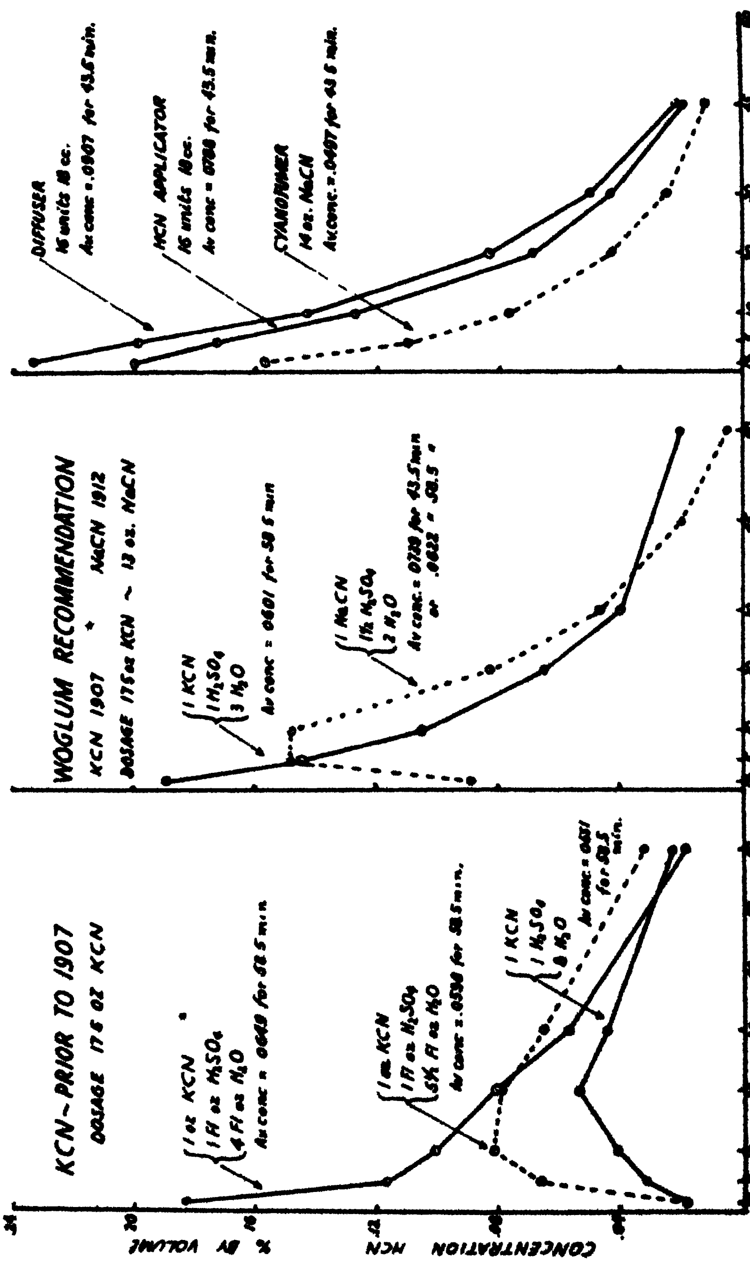

FIG. 107.—Concentrations of hydrocyanic acid by different methods used in California at different times.

fluid ounces of water to each fluid ounce of sulphuric acid. He found 2 fluid ounces of water too small a quantity to dissolve the potassium sulphate formed by the reaction and that with larger amounts of water the percentage of hydrocyanic acid generated from the potassium cyanide was diminished. He selected the 1–1–3 formula as most suitable. In a later paper, Woglum (11) discussed sodium cyanide and gave the formula for its use as 1–1½–2. The Cyanofumer followed shortly after the introduction of sodium cyanide. In this machine, the sodium cyanide was dissolved in water and by the working of a lever, a definite amount of sodium cyanide solution was dumped into the large generator containing the acid. The gas was given off with a rush and the machine passed on to the next tree. Liquid Hydrocyanic acid followed the Cyanofumer. It is applied in two ways. One method, known locally as "cold gas," consists of atomizing the liquid through spray nozzles under the tent. The other method, known as "hot gas," passes the measured amount of liquid through coils heated with steam at 20 lbs. pressure. These heated coils vaporize the liquid and the gas under pressure is delivered through a distributing nozzle. This is called a Diffuser.

Working with a form tent of approximately 2000 cu. ft. capacity, 38 ft. over and 44 ft. around (16 unit size), a study has been made of the types of concentration obtained by the different methods and with the different dosages. Concentration curves for the different methods and dosages are shown in Fig. 107. It will be noted that in early fumigation practice, due to the use of large quantities of water, a gradual evolution of the gas was obtained. The entire course of development of fumigation practice has been away from this type of concentration toward a high concentration quickly obtained. With a peak concentration quickly reached and no gas given off after the start, to replace that loss by tent leakage, the concentration drops rapidly. This factor resulted in lowering the fumigation period from one hour to 45 minutes. With the Cyanofumer all the gas was released at once. This machine gave the lowest concentrations of any of the methods, due to the retention of gas in the acid mixture in the generator. The amount of this gas was so large that when the spent generator was dumped, the mixture could be ignited. The use of "hot gas" in the Diffuser gave the highest concentration evenly distributed in the shortest period of time.

Knight (6) has pointed out that the kill of insects is related to a constant obtained by multiplying the concentration of gas by the length of exposure. Brinley and Baker (1), working with other insects, have found the same relationship. Taking the known concentrations from the preceding curves, that is, from 1½ min. after the application to the end

of the period, the following constants were obtained for the various methods:

3.22 for KCN 1-1-8	58.5 min.	period	
3.50 for KCN 1-1-5½	"	"	"
3.79 forKCN 1-1-4	"	"	"
3.52 for KCN 1-1-3	"	"	"
3.64 for NaCN 1-1½-2	"	"	"
3.45 for NaCN 1-1½-2	43.5	"	"
2.16 for Cyanofumer	"	"	"
3.41 for Liquid HCN applicator	"	"	"
3.95 for Liquid HCN Diffuser	"	"	"

The constant varies from 2.16 to 3.95 with an average of 3.4.

In the case of the Cyanofumer and the Diffuser, the dosage is well distributed throughout the tent almost at once, hence the first 1½ minutes should be considered. Projecting the concentration from 1½ min. to the start, the constant for the Cyanofumer becomes 2.4 instead of 2.16 and for the Diffuser 4.31 instead of 3.95. With these corrections, the average constant becomes 3.47. These figures indicate that during the history of fumigation in California, although different dosages and materials and methods of application have been used, the constant, time x concentration, has varied but little.

Gray and Kirkpatrick (4) found that exposure of red scale to low concentrations of hydrocyanic acid created a condition in the insects making them more difficult to kill. This effect they named "protective stupefaction." This condition may be brought about in two ways. The insects on near-by trees may be exposed to gas leaking from the tents during a fumigation. This is known as drift gas and many field tests have shown this to be the chief cause of poor kills resulting from stupefaction. The other cause of stupefaction is the exposure of the insects to sub-lethal concentrations due to faulty distribution of the gas within the tent during the fumigation. Faulty distribution of the gas may result from the use of "cold gas" during winter daylight fumigation when the temperature of the soil is much lower than the air temperature. The evaporation of the atomized liquid hydrocyanic acid produces a cooling effect causing the gas to stratify at the bottom of the tent. If the soil is warmer than the air, the usual condition during night fumigation, the gas is carried up by convection currents arising from the warmer soil. If the soil is cooler than the air, the gas remains at the bottom of the tent and the upper parts of the tree are exposed to low and irregular concentrations. To overcome this difficulty, the Diffuser is

used which not only delivers the hydrocyanic acid under the tree as a gas but also gives an immediate uniform distribution of the gas under the

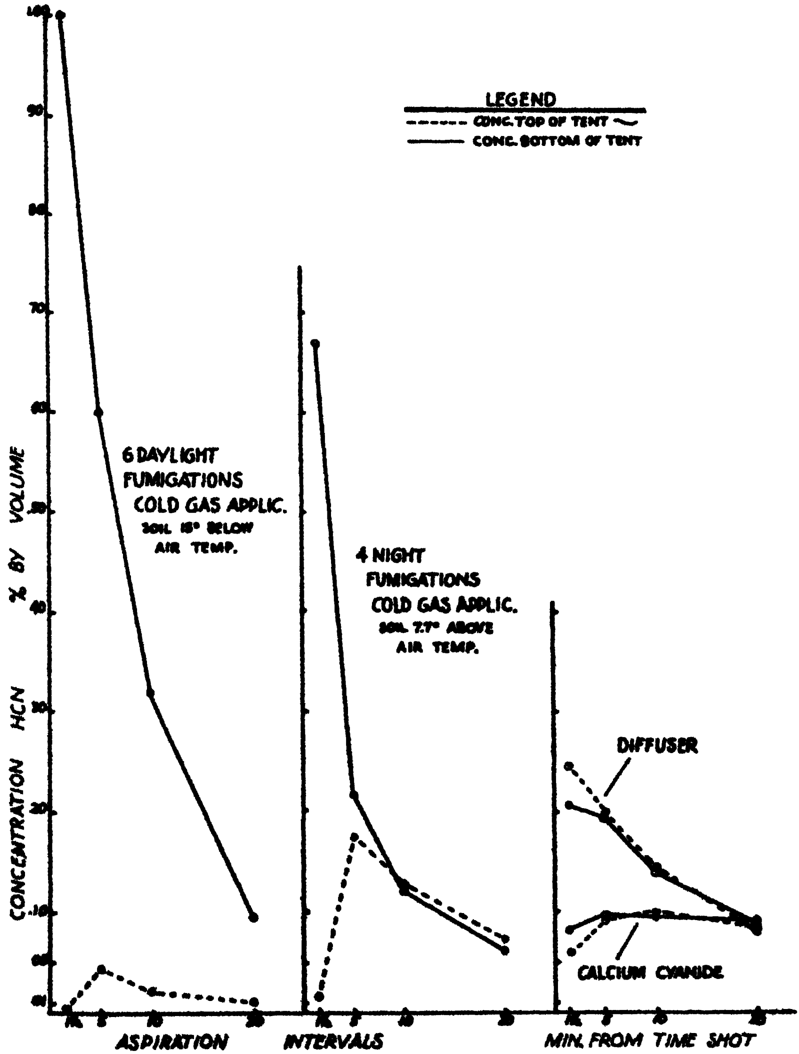

FIG. 108.—Concentrations of hydrocyanic acid at the top and bottom of the tent under different soil conditions and methods.

tented surface. Fig. 108 shows the gas concentrations at the top and bottom of the tent for the atomized liquid hydrocyanic acid during unfavorable and favorable conditions and the uniform distribution of gas when vaporized and distributed by the Diffuser.

Gray and Kirkpatrick (4) considered protective stupefaction due to faulty gas distribution more wide-spread than has been shown to be the case. In night fumigation, carefully checked tests have failed to show an advantage of the hot gas over the cold gas. The use of the Diffuser by commercial fumigators for four years has not shown a consistent difference in night work between the Diffuser and the cold gas applicator. In daylight work, where the soil is cold, the Diffuser has shown better results.

Experiments were performed to determine the effect of changing the type of concentration from a quick, high concentration quickly leaking away to a lower concentration gradually built up and better maintained. Both types of concentration may be obtained from calcium cyanide. One form of calcium cyanide containing approximately 50% CN releases most of its hydrocyanic acid at the time the dust is blown under the tent. This gives a quick, high concentration which is quickly lost since tent leakage is not replaced by further gas evolution. The other form of calcium cyanide containing approximately 25% CN gives off only about 30%–40% of its hydrocyanic acid in the first minute and the concentration is gradually built up during the first ten minutes due to further evolution of hydrocyanic acid.

Comparative tests were made upon orange trees at Azusa using such quantities of each type of calcium cyanide that its hydrocyanic acid content was approximately 50% of the liquid hydrocyanic acid schedule for California.

TABLE 2. COMPARISON OF TWO TYPES OF CONCENTRATION FROM TWO FORMS OF CALCIUM CYANIDE

Time	Temp.	Rel. Hum.	Exposure	Type of concentration	Kill on fruit
7.30 P.M.	53°	87.5%	45 min.	Quick, high	98.02% ±.30
7.30 P.M.	53°	87.5%	45 min.	Gradual maintained	99.72 ±.07
3.10 P.M.	63°	60%	45 min.	Quick, high	97.72 ±.19
3.10 P.M.	63°	60%	45 min.	Gradual maintained	98.74 ±.13
4.30 P.M.	67.5°	48%	45 min.	Quick, high	98.92 ±.19
4.30 P.M.	67.5°	48%	45 min.	Gradual maintained	98.32 ±.14
4.32 P.M.	62°	38%	45 min.	Quick, high	97.91 ±.20
4.32 P M.	62°	38%	45 min.	Gradual maintained	99.00 ±.10

In three of the four tests, the differences were in favor of the lower concentration maintained rather than the quick, high concentration. These differences may not be due to the type of concentration but due to the loss of hydrocyanic acid at the time of application. When a calcium cyanide dust is blown under a tent a considerable volume of air is introduced by the blower resulting in air being forced out of the tent.

Using a material with a rapid evolution of gas, considerable hydrocyanic acid is lost immediately, thus reducing the effective dosage.

Comparisons were made between liquid hydrocyanic acid producing a quick high concentration and calcium cyanide distributed on the ground by means of a shaker, giving a low, well maintained concentration. This method of using calcium cyanide gives a concentration curve similar to the KCN curve where extra water was added to the acid. Unlike the KCN curve, it has a very uniform concentration in different parts of the tent. (Fig. 108.) In using calcium cyanide the exposures were 1–1½ hours comparable to the customary exposures with KCN; with liquid hydrocyanic acid, the exposure was for 45 minutes, comparable to the present day practice. In these tests, the same quantity of hydrocyanic acid was used either in the form of liquid or calcium cyanide. The first tests were on lemon trees at La Habra.

TABLE 3. COMPARISON OF CONCENTRATION FROM CALCIUM CYANIDE AND LIQUID HCN

Time	Condition	Material	Kill
6 P.M.	Temp. 64° Rel. Hum. 74% Soil 66°–76°	Liquid HCN 100% dosage Cold Gas applicator 45 min. exposure	99.05% ±.03
		Calcium cyanide applied on ground 1½ hrs. exposure. Equivalent to 100% liquid dosage	99.03% ±.15
6.14 P.M.	Temp. 61° Rel. Hum. 89% Soil 64°–73°	Liquid HCN 100% dosage Cold Gas applicator 45 min. exposure	99.41% ±.1
		Calcium cyanide applied on ground. 1½ hrs. exposure. Equivalent to 100% liquid dosage	99.06% ±.12

Another test was made November 22, 1932 at Glendora under conditions giving poor kills.

TABLE 4. COMPARISON OF DIFFERENT TYPES OF CONCENTRATION

Time P.M.	Temp.	Rel. Hum.	Soil	Material	Dosage	Exposure	Kill
3.40	72°	34%	70–72°	Cold gas	100%	45 min.	87.91% ±.55
3.40	72°	34%	70–72°	Hot gas	100%	45 min.	93.88% ±.45
3.50	70°	40%	70–72°	Calcium cyanide	100%	1½ hrs.	93.45% ±.37
3.55	70°	40%	70–72°	Calcium cyanide	100%	1 hr.	93.11% ±.38
4.30	65°	44%	68–71°	Cold gas	100%	45 min.	88.42% ±.55
4.30	65°	44%	68–71°	Hot gas	100%	45 min.	87.94% ±.54

A significantly better kill was obtained by the use of the Diffuser over the kill with cold gas when the soil temperature was the same or lower than the air temperature but there was no difference between the results obtained with either the cold gas or the hot gas when the soil temperature was above the air temperature. There was no significant difference in

the results from calcium cyanide applied on the ground and the liquid hydrocyanic acid applied with the Diffuser at the same time. The con-

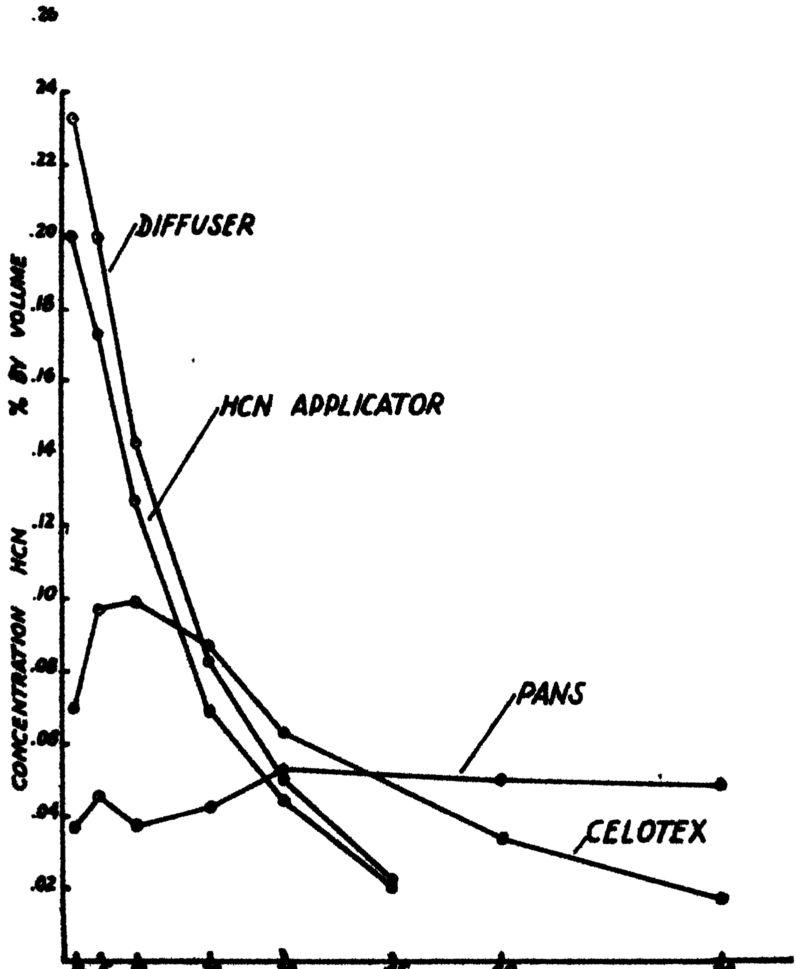

FIG. 109.—Concentrations obtained in applying liquid hydrocyanic acid by different methods.

centration curves from these two materials are entirely different (Fig. 108). Soil and air temperature relations, unfavorable to the use of liquid hydrocyanic acid by the cold gas applicator, were not unfavorable to the use of calcium cyanide.

Another method of changing the type of concentration is to remove the nozzles from the regular liquid applicator and pump the dosage out upon porous Celotex or into pans placed under the tent. The liquid hydrocyanic acid evaporating from either the Celotex or the pans gives an entirely different concentration than is obtained by either the cold or hot gas application. (Fig. 109.) Fumigation by these methods for 90 minutes produces time x concentration constants comparable to those from regular methods for 45 minutes.

Diffuser	43.5 min.	=	3.95
Liquid application	43.5 "	=	3.41
Pumped onto Celotex	88.5 "	=	3.38
Pumped into pans	88.5 "	=	4.28

Tests of these methods were made at La Habra October 6 and 8, 1932.

TABLE 5. COMPARISON OF DIFFERENT TYPES OF CONCENTRATION FROM LIQUID HCN

Time	Temp.	Rel. Hum.	Soil	Method	
6.37 P.M.	61°	89%	64-73°	Regular cold gas applicator	99.40%±.10
6.30 P.M.	61°	89%	64-73°	Evaporating from Celotex	99.02%±.14
6.33 P.M.	61°	89%	64-73°	Evaporating from pans	97.62%±.25
6.32 P.M.	61°	78%	64-71°	Regular cold gas applicator	99.67%±.16
6.13 P.M.	61°	78%	64-71°	Diffuser	99.59%±.10

These results confirm the former tests, that the type of concentration makes no significant difference providing there is no faulty distribution of the gas. The slow evaporation from the pans gave abundant opportunity for protective stupefaction, since the concentration was low throughout the test. This is reflected in the kill by this method.

The conclusion is reached that, providing proper distribution of the gas is obtained within the tent, the type of concentration curve has no significant influence on the kill. The low concentration gradually rising, as with calcium cyanide applied on the ground or liquid hydrocyanic acid evaporating from a porous material, gave the same results as the quick, high concentration of the Diffuser. This was observed under conditions giving low, as well as high, kills.

In order to determine the advantages of low concentration or high concentration, laboratory tests were made under controlled conditions. For these tests, the metal box described by Gray and Kirkpatrick (4) was used. Certain changes were made in the set-up. Metallic mercury was substituted for the oil seal. In applying the dosage, the liquid hydrocyanic acid was first measured into a little chamber, instead of the flask, and the entire dosage was then dropped into a coil heated with

boiling water. By this method, the entire dosage was blown into the box in a few seconds and uniform distribution was assured by means of a fan. This procedure permitted short exposures with high concentrations since all concentrations reached their maximum in all parts of the box in a matter of seconds.

The fumigations were carried out on lemons collected at Corona, the area in which "resistant" red scale was first found. The lemons were attached by wires to iron stands so that no lemon touched another lemon

TABLE 6. KILLS OBTAINED BY DIFFERENT TIME-CONCENTRATION CONSTANTS

Time in minutes	Concentration per cent by volume	Exposure x concentration	Kill	
60	.2013	12.078	100.00%	
7	1.4843	10.390	98.95	±.30
45	.1597	7.186	98.88	±.33
90	.0698	6.282	98.29	±.47
10	.5865	5.865	99.01	±.30
5	1.1549	5.774	100.00	
90	.0602	5.418	95.40	±.68
60	.0779	4.974	99.89	±.11
10	.4865	4.865	99.73	±.15
45	.1080	4.860	96.63	±.65
30	.1619	4.857	95.87	±.67
90	.0516	4.644	91.77	±.86
20	.2288	4.576	98.52	±.40
5	.9028	4.514	96.72	±.59
90	.0438	3.942	97.16	±.52
45	.0861	3.874	*100.00	
90	.0294	2.646	96.51	±.55
90	.0220	1.978	†98.99	±.38

*18 cc schedule with Diffuser under tent.
†Calcium cyanide under tent.

or any other object, thus exposing all insects equally. Concentrations from 1.48% to .0294% by volume and time periods of 5 to 90 minutes were used. Fumigations were made between Dec. 19 and Dec. 31, 1932, between the hours of 10 A. M. and 4 P. M. The temperature range was 53°–70° F., under conditions considered as favorable for daylight winter fumigation. In addition to the metal box fumigations, two runs were made in the form tent, one using liquid hydrocyanic acid applied with the Diffuser and the other with a low concentration obtained from calcium cyanide applied on the ground. The results of the series are given in Table 6. This table is arranged in the order of time x concentration constant.

There is no regularity of results even considering a definite time interval. Many of these dosages are far above the tree tolerance and yet perfect kills were not obtained. The results do not discredit the time x concentration constant but merely indicate that there was some un-

controlled factor influencing the success of a fumigation which overshadowed the time x concentration constant. In other words, if conditions are unfavorable, increasing the dosage or the time will not insure a perfect kill.

Preceding each of the fumigations, a set of lemons was prefumigated with a concentration of .015 to .02% by volume for a period of 20 min., to produce protective stupefaction. These prefumigated lemons were then fumigated along with others not prefumigated, in the same box. In Table 7, the two sets of lemons are arranged first according to length of exposure and second according to the kill of insects not prefumigated.

TABLE 7. THE EFFECT OF EXPOSING "RESISTANT" RED SCALE TO A LOW CONCENTRATION

Time	Concentration per cent by volume	Not pre-fumigated	Pre-fumigated	Kill
5	1 1549	100.00%	98.48% ±.4	—1.52*
5	.9028	96.72 ±.59	97.69 ±.45	+0.97
30	.1619	95.87 ±.67	98.73 ±.38	+2.86
45	.1597	98.88 ±.33	99.31 ±.26	+0.43
45	.1080	96.63 ±.65	98.71 ±.31	+2.08
45	.0861	100.00	98.58 ±.35	—1.42*
60	.2013	100.00	99.72 ±.1	—0.28
60	0779	99.89 ±.11	98.17 ±.4	—1.72
90	0602	95.40 ±.68	97.89 ±.42	+2.49
90	0516	91.77 ±.86	98.58 ±.48	+6.81*
90	0220	98.99 ±.38	91.42 ±.90	—7.57*
		100.00%	98.48%	—1.52%*
		100.00	99.72	—0.28
		100.00	98.58	—1.42*
		99.89	98.17	—1.72*
		98.99	91.42	—7.57*
		98.88	99.31	+0.43
		96.72	97.69	+0.98
		96.63	98.71	+2.08
		95.87	98.73	+2.86
		95.40	97.89	+2.49
		91.77	98.78	+6.81*

*Indicates significant differences.

Under conditions giving high kills prefumigation reduced the kill. Above 98% there were 4 significant negative differences and two without differences. Below 98%, the differences are all positive but only one is significant. These results indicate that exposure to low concentrations preceding the regular fumigation does not always reduce the kill and field results confirm these conclusions.

THE INFLUENCE OF STAGES OF DEVELOPMENT UPON THE KILL.—Unpublished studies by several entomologists have indicated that certain stages of the "resistant" red scale are more difficult to kill than others. This was particularly true for the late second molt and the early grey

adult. The question arises as to whether the kill obtained in actual orchard fumigation is related to the percentage of the scale in these stages of development.

The following field fumigations are arranged to show this relationship if it exists.

TABLE 8. INFLUENCE OF PERCENTAGE OF RESISTANT STAGES UPON THE KILL

Per cent resistant stages	Place	Kill
14.50	Glendora	50.94%-94.04%
14.89	Corona	100%
19.20	La Habra	99.51%
22.80	La Habra	98.06%
24.50	La Habra	99.81%
45.50	Corona	89.03%-95.97%
56.00	Corona	95.69%

Where different kills are indicated as at Glendora and Corona, they represent the highest and lowest in a series of fumigations on the same day. Clearly the stage of development is not the controlling factor when, with the same dosage and without a drift gas effect, the kill can vary from 50% to 94% in the same day. Live insects which were in these resistant stages at the time of fumigation are more frequently encountered than others. It would appear as if conditions at the time of the fumigation decide its success or failure and the stage of development of the insect decides whether it will or will not be a survivor of an unsuccessful fumigation.

INFLUENCE OF THE TEMPERATURE OF THE LEMON UPON THE KILL — During the box fumigations recorded in Table 6, the nights were generally cold. It was observed that in general better kills were obtained in

TABLE 9. A COMPARISON OF THE FUMIGATION OF INSECTS KEPT UNDER COOL AND WARM CONDITIONS PRECEDING THE FUMIGATION

Time	Concentration per cent by volume	Lemons from warm room	Lemons from outside
9.22 A.M.	.0367	62.32% ±1.37	84.33% ±1.00
10.22 A.M.	.0807	93.65% ± .54	97.75% ± .43
11.19 A.M.	.0613	87.70% ± .81	92.87% ± .74
1.11 P.M.	.0506	80.69% ±1.16	94.00% ± .57
2.09 P.M.	.0331	79.35% ±1.2	77.76% ±1.03
3.08 P.M.	.0934	96.93% ± .42	97.68% ± .35

the afternoon, particularly late afternoon than earlier in the day. Following a cold night, it might be that a number of hours of increased temperature were necessary to activate the insects. Then insects on lemons kept during the night in a warm room should be easier to kill than those on lemons exposed to the normal low night temperatures when fumi-

gated together. Lemons for this experiment were obtained from Corona. They were divided into two lots, one being placed in a room heated to 70°–75° F, the other exposed to normal night temperatures. The following day a series of 45 min. fumigations was conducted in the metal box with different concentrations.

The first four tests showed significant differences, the last two no differences. In attempting to determine how long a period of heating was necessary to produce these results, it was found that there was a lag in the temperature of the lemon compared with the air temperature. A lemon at a temperature of 51.8° F., brought into a room heated to 75° F., showed a temperature of 64° at the end of 1 hour, 67° at 2 hours, 72.5° at 3 hours and 4 hours.

TABLE 10. THE RESULTS OF FUMIGATING LEMONS AT DIFFERENT TEMPERATURES ABOVE THE AIR TEMPERATURE

Degrees lemon temperature above air temperature	Kill	Degrees lemon temperature above air temperature	Kill
11.4°	94.36%	2.5°	80.08%
9.0	94 93	2.3	88.37
8.0	88.98	1.7	95.02
7.6	96.05	1.6	92.51
7.5	88.99	1.6	98.67
5.6	67.38	0.7	97.61
5.1	86.36	0.5	95 60
3.5	91.14	0.5	97.22
3.1	98.16	0.4	97.68
2.6	93.26	0.2	95.91

A series of 45 minute fumigations was made with Corona lemons all at approximately the same concentration .0802 to .0870% by volume. Fumigations were carried out on two days at different times of the day and night. Lemons used in these tests were all at different temperatures higher than the temperature of the fumigation chamber.

In general, the greater the difference between the lemon temperature and the box temperature the lower the kill. This is apparently a factor of some importance.

An experiment similar to that of Table 9 was repeated with lemons of known temperatures. In carrying out this test lemons were obtained from Corona to represent "resistant" red scale and from La Canada to represent "non-resistant" red scale. Sets of each were fumigated together.

Different kills are apparent in these sets but they are not correlated with the magnitude of the difference between the temperature of the lemon and the air temperature. The "non-resistant" insects from La Canada showed little reaction to changed temperature conditions.

Lemons under actual fumigation conditions may be at higher or lower temperatures than the air temperature due to sudden changes in

TABLE 11. THE SIMULTANEOUS FUMIGATION OF WARM AND COOL LEMONS WITH "RESISTANT" AND "NON-RESISTANT" RED SCALE

Time	Concentration per cent by volume	Degrees difference lemons minus air temperature	Kill of insects on Corona lemons	Kill of insects on La Canada lemons
9.16 A.M.	.0729	+13.0	63.45%± .71	94.75%±.48
		− 6.4	78.26%±2.37	96.89%±.40
10.46 A.M.	.0608	+ 2.3	36.88%±2.57	97.54%±.36
		− 4.0	87.59%±2.68	94.71%±.52
3.15 P.M.	.0589	+ 8.0	51.88%±2.67	99.88%±.08
		− 1.0	77.05%±2.57	100.00%
5.20 P.M.	.0683	+15.8	71.70%±2.41	100.00%
		+ 1.8	89.57%±1.92	100.00%
8.51 A.M.	.0977	+15.1	96.09%± .69	100.00%
		+ 4.3	97.33%± .59	99.82%±.08
		− 6.5	99.72%± .21	
2.11 P.M	.0984	+ 6.5	98.88%± .38	99.91%±.08
		+ 4.5	96.37%± .67	98.76%±.29
		− 5.4	98.06%± .49	99.73%±.18
8.30 P.M.	.0815	+24.2	97.77%± .53	99.79%±.14
		− 1.9	96.37%± .67	99.51%±.19
		− 2.8	94.90%± .79	99.66%±.16

the air temperature or to the sun shining upon the lemon. A fumigation was conducted at Glendora at different times of day and night. The lemons were picked so as to represent those in the sunshine during the day for comparison with those in the shade. Natural mortality counts were made on the same basis.

TABLE 12. THE FUMIGATION OF LEMONS IN THE SUN AND SHADE PRECEDING TREATMENT

Time	Lemons in sun during day Lemon temp. minus air temp.	Kill	Lemons in shade during day Lemon temp. minus air temp.	Kill
5.08 P.M.	+ 2.7°	80.75%±.70	+2.7°	78.19%±.72
11.00 A.M.	+10.6	99.26%±.19	−2.0	96.90%±.38
1.00 P.M.	+10.6	94.38%±.55	+2.2	98.78%±.19
3.00 P.M.	+ 9.5	89.37%±.68	+1.4	96.34%±.47
5.00 P.M.	+ 9.3	98.79%±.23	+3.0	97.85%±.41
3.00 P.M.	+12.2	96.75%±.46	+1.4	96.08%±.48
4.00 P.M.	+11.7	97.09%±.39	+1.8	99.80%±.10
5.00 P.M.	+ 8.6	96.41%±.48	+2.9	98.57%±.28
6.00 P.M.	+ 5.2	96.09%±.38	+0.9	89.13%±.70
9.00 P.M.	− 2.0	94.62%±.49	−1.7	89.59%±.66
Natural mortality..	...	93.59%±.12		94.01%±.11

In five cases the lemons at the higher temperature had the poorest kill and in two cases, those with the lower temperature showed the poorest kill. In two cases there was no difference.

It would appear from the data presented that the temperature of the lemon compared with the air temperature is not the controlling factor in

the kill. Under conditions giving poor kills the lemons showing the greater positive temperature differences exhibited the lower kills.

INFLUENCE OF TEMPERATURE AND RELATIVE HUMIDITY UPON THE KILL.—The effect of temperature and relative humidity was the subject

TABLE 13. FUMIGATION OF "RESISTANT" RED SCALE AT DIFFERENT TEMPERATURES

Concentration per cent by volume	Time	Temperature	Rel. Hum.	Kill
.0802	2.00 P.M.	64.0°	51.0%	87.88%
.0854	4.00 P.M.	62.0	52.0	89.96
.0820	5.00 P.M.	58.5	32.5	92.51
.0815	8.30 P.M.	58.5	44.0	94.90
.0859	6.00 P.M.	55.5	40.0	88.37
.0849	7.00 P.M.	55.5	36.0	95.02
.0867	9.00 A.M.	54.0	64.0	87.50
.0848	8.00 P.M.	54.0	35.0	97.68
.0853	9.00 P.M.	53.5	33.0	95.60
.0845	10.00 P.M.	53.5	28.8	97.22
.0828	1.00 A.M.	53.5	23.8	98.67
.0807	10.22 A.M.	53.0	60.3	97.73
.0845	12.00 P.M.	52.0	29.0	97.61
.0836	11.00 P.M.	51.5	36.9	95.91
.0836	3.00 A.M.	44.0	52.5	98.16

TABLE 14. FUMIGATION WITH LOW CONCENTRATION OF "RESISTANT" AND "NON-RESISTANT" RED SCALE AT DIFFERENT TEMPERATURES

Concentration per cent by volume	Time	Temp.	Rel. Hum.	Kill of resistant red scale	Kill of non-resistant red scale
.0633	12.44 P.M.	75°	27%	56.05%	99.45% ±.21
.0591	1.32 P.M.	70	33	91.04	99.18 ±.28
.0589	1.45 P.M.	66	36	56.60	98.90 ±.23
.0589	3.15 P.M	66	36	77.05	100.00
.0629	10.19 A.M.	66	36	89.69	——
.0578	12.15 P.M.	64	38	65.71	98.91 ±.24
.0608	10.46 P.M.	62	45	87.59	94.71 ±.52
.0564	12.49 P.M.	62	91	88.49	——
.0508	1.11 P.M.	60	48	94.00	——
.0575	10.22 A.M.	59	62	92.89	——
.0683	5.20 P.M.	59	52	89.57	100.00
.0608	8.51 P.M.	58	54	90.98	99.67 ±.15
.0613	11.19 A.M.	56	55	92.83	——
.0598	9.35 P.M.	55	43	95.69	100.00

of study in a number of 45 minute fumigations during the winter of 1932–33 with "resistant" insects from the same orchard in Corona. Different concentrations were used at different times. Concentrations nearly equal and produced by the same dosage of hydrocyanic acid were arranged according to the temperature at which the fumigation was conducted. Tables 13 and 14 give the results for two different concentrations arranged according to the temperature. Table 14 also contains

the results with "non-resistant" red scale from La Canada fumigated with the "resistant" red scale from Corona.

A general upward trend in kill is noted with lower temperatures. There also appears to be a relationship between the kill and the time of day. In Table 13 at the same temperature of 54° and on the same day the kill is much better at 8 P. M. than at 9 A. M. The same set of figures shown in Table 14 is rearranged in Table 15 upon the basis of relative humidity.

TABLE 15. INFLUENCE OF RELATIVE HUMIDITY

Concentration per cent by volume	Time	Temperature	Rel. Hum.	Kill
.0564	12.49 P.M.	62°	91%	88.49%
.0575	10.22 A.M.	59	62	92.89
.0613	11.19 A.M.	56	55	92.83
.0608	8.51 P.M.	58	54	90.98
.0683	5.20 P.M.	59	52	89.57
.0508	1.11 P.M.	60	48	94.00
.0608	10.46 A.M.	62	45	87.59
.0598	9.35 P.M.	55	43	95.69
Average. .	....	..		91.50%
.0578	12.15 P.M.	64°	38%	65.71%
.0629	10.19 A.M.	66	36	89.69
.0589	1.45 P.M.	66	36	56.60
.0589	3.15 P.M.	66	36	77.05
.0591	1.32 P.M.	70	33	91.04
.0633	12.44 P.M	75	27	56.05
Average.	....	....	....	72.69%

It will be noted that above 40% relative humidity the kills are quite consistent. Below 40% relative humidity the kills are low with two exceptions. An examination of these two exceptions reveals the fact that on these two days the relative humidity had come to its low in a gradual slope and soon rose again. In the other four cases the relative humidity had reached 40% by 7 A. M. and had remained below 40% for at least 12 hours during the day.

Another indication of the effect of low relative humidity was obtained by two fumigations of lemons from Fullerton.

Relative humidity preceding fumigation	Temp.	Rel. Hum.	Kill
Below 40% for 1 hour..........	76°	38%	98.05% ± .32
Below 40% for 2½ hours........	76°	34%	93.28% ± .52

In another experiment lemons from Fullerton were kept for eight hours in containers where the relative humidity was controlled by pass-

ing the incoming air through sulphuric solutions or over sulphuric acid and calcium chloride. These lemons were then fumigated for 45 minutes in the metal box at a temperature of 62° and a relative humidity of 66.5% at 6:37 P. M. Following the fumigation, these lemons were returned to the containers with controlled humidity for a period of 14 hours.

TABLE 16. EFFECT OF RELATIVE HUMIDITY BEFORE AND AFTER THE FUMIGATION

Preceding fumigation	After fumigation	Concentration per cent by volume	Kill
Rel Hum. 73%-78%	Rel. Hum. 73%-80%	.0666	98.36%±.15
" 73% 78%	" 34%-38%	.0666	98.66%±.14
" 28%-35%	" 73%-80%	.0666	96.80%±.23
" 28%-35%	" 34%-38%	0666	95.72%±.30

Bearing on this same point, two fumigations on different nights in the same orchard at the same temperature but different relative humidities gave unequal kills.

5 P M.	56° F.	60% Rel. Hum.	98.27%
7 P. M.	56° F.	30% Rel. Hum	89.30%

These various tests indicate that both temperature and relative humidity are factors determining the success of the fumigation. The exact extent of the influence of each factor is not clearly defined.

EFFECT OF TEMPERATURE BEFORE AND AFTER THE FUMIGATION.—A set of lemons was placed in an ice box, a second set was hung by wires in the bright sunshine, a third set was placed in the shade in a screen room and a fourth set was placed in a room heated to 95° F. The lemons were from Corona, representing "resistant" red scale and from La Canada representing "non-resistant" red scale. Lemons from each source were fumigated together and then divided into sets placed under different conditions. Table 17 The cool chamber ran at 45° F. during the day and lower at night. The screen room reached a maximum temperature of 83° at 12:30 P. M., 78° at 4 P. M. and 59° at 7 P. M. 54° at 9 P. M. and a minimum of 51° during the night.

It appears that the high day temperature and low relative humidity had the greatest influence upon the kill but there are indications that cold following the fumigation will reduce the kill. One point should be mentioned, namely, that in bringing the cold lemons from the 8:51 P. M., fumigation into the warm room there was some condensation of moisture upon them. This moisture should have quickly evaporated since the relative humidity in the room was 41%.

TABLE 17. INFLUENCE OF TEMPERATURE CONDITIONS BEFORE AND AFTER FUMIGATION

Conditions	Conditions preceding fumigation	Conditions after fumigation	Kill resistant	Kill non-resistant
Temp. 64.5°F.	Cool chamber 45°	Cool chamber	84.15%±1.36	95.68%±.69
Rel. Hum. 38.5%		Screen room	91.35%± .98	98.77%±.31
Lemon temp. 49°		Sun	91.62%±1.0	98.47%±.42
Concentration .0660				
Time 9.18 A.M.				
Temp. 68.5°F.	In sun	Cool chamber	67.30%±1.45	98.62%±.35
Rel. Hum. 36.5%		Screen room	74.76%+1.45	98.65%±.29
Lemon temp. 78.8–75°		Sun	74.27%±1.50	99.33%±.23
Concentration .0592				
Time 10.23 A.M.				
Temp. 75°F.	In screen room	Cool chamber	62.45%±1.53	97.61%±.38
Rel. Hum. 27%	Shade	Screen room	56.05%±1.66	99.45%±.21
Lemon temp. 77°		Sun	71 71%±1.34	97 31% ± 44
Concentration .0633				
Time 12.44 P.M.				
Temp. 61°F.	In heated room	Cool chamber	85.03%±1.24	99.33%±.18
Rel. Hum. 45%	95°F.	Screen room	80.05%±1.20	99.88%±.08
Lemon temp. 91.4°		Heated room	96.99%± .55	99.82%± 12
Concentration .0684				
Time 7.48 P.M.				
Temp. 58°	In screen room	Cool	90.55%± .89	100.00%
Rel. Hum. 53.8%		Screen room	90.98%± .86	99.67%±.15
Lemon Temp. 61.5°		Heated room	98.01%± 44	99.70%±.14
Concentration .0608				
Time 8.51 P.M.				

One field experiment indicates the effect of low temperature following a fumigation.

Feb. 21, 1933	9 P. M.	49° F.	74% Rel. Hum.		92.08% Kill
Feb. 9, 1933	5 P. M.	52° F.	75%	" "	75.68% Kill

The conditions of the experiment were nearly the same on both dates, but on Feb. 21, the temperature did not fall below 48° all night, whereas on the 9th, the temperature fell rapidly reaching a low of 38°F. during the night. From these observations it would appear that temperature and humidity conditions preceding fumigation and temperature conditions after the fumigation had a bearing upon the kill.

COMPARISON OF "RESISTANT" AND "NON-RESISTANT" RED SCALE.—The real difference between the "resistant" and "non-resistant" red scale is brought out by the different kills obtained under different conditions and treatments as shown in Table 18. The concentrations range from .0591 to .0684 for 45 minutes exposure. This gives a time x concentration constant of 2.65 to 3.08 whereas the normal constant used in

fumigation is 3.41 to 3.95. With the "resistant" strain the kill may fall very low under unfavorable conditions such as high temperature, low relative humidity, pre-exposure to low concentrations, exposure to low relative humidity, preceding the fumigation or low temperatures following the fumigation. Under the same conditions, the "non-resistant" red scale reacts but slightly. Under favorable conditions, the kills of "resistant" and "non-resistant" scale may show no significant difference even with this low concentration.

TABLE 18 THE REACTION OF "RESISTANT" AND "NON-RESISTANT" RED SCALE TO DIFFERENT ENVIRONMENTAL CONDITIONS

Conc. % by vol.	Time	Temp.	Rel. Hum.	Prefumigation treatment	Post-fumigation treatment	"Resistant"	"Non-resistant"
.0633	12.44 P.M.	75°	27%	Normal	Normal	56.05% ±1.66	99.45% ±.21
.0591	1.32 P.M.	70	33	Prefumigated	Normal	60.45% ±1.75	98.31% ±.04
.0591	1 32 P.M.	70	33	Not prefumigated	Normal	91.04% ± .87	99.18% ±.28
.0592	10.23 A.M.	68.5	36.5	Sun	Cool box 45°	67.30% ±1.45	98.62% ±.35
.0592	10.23 A.M	68.5	36.5	Sun	Sun	74.27% ±1.50	99.33%. ±23
.0608	8.51 P.M.	58	53.8	Cool scrn. room	Cool scrn. room	90.98% ± .86	99.67% ±.15
.0608	8.51 P.M.	58	53.8	Cool scrn. room	Heated room	98.00% ± .44	99.70% ±.14
.0598	9.35 P.M.	55	43	Exposed to low Rel. Hum.	Normal	88.00% ±1.13	100.00%
.0598	9.35 P.M.	55	43	Normal	Normal	95.69% ±. 65	100.00%

Brinley and Baker (1) have shown with aphids and thrips that the kill resulting from treatment with hydrocyanic acid increased with temperature. Metabolic processes increase with an increase in temperature and since hydrocyanic acid affects the metabolic processes one would expect an increase in susceptibility with an increase in temperature. The data presented indicate the reverse to be the situation, namely, that higher kills are more frequently the result of fumigations at lower temperatures.

Moore (8) working with tender greenhouse plants found that plant injury may be prevented by fumigations at high temperatures and low relative humidities. High temperatures and low relative humidities reduce the absorption of the gas by the cuticle of the plants, whereas low temperatures and high relative humidities favor the absorption. A moist object will absorb more hydrocyanic acid than a dry object.

While chemical effects are increased by an increase in temperature, absorption and adsorption are increased by a lowering of the temperature.

With the data accumulated to date, it would appear that the difficulty of killing the "resistant" red scale was due to the difficulty of reaching the insect through its scale rather than to any distinct immunity of the insect itself to hydrocyanic acid. Under conditions favorable to the absorption or adsorption of hydrocyanic acid, the "resistant" and "non-resistant" red scale may be killed equally well but under conditions unfavorable to absorption but favorable to the action of hydrocyanic acid on the tissues of the insect, the kill of "resistant" red scale falls off whereas the kill of "non-resistant" red scale is reduced little, if any.

Assuming that in certain areas due to climatic conditions, the red scale secreted a larger quantity of wax than those in other areas, thus developing a covering more difficult to penetrate, we would have "resistant" and "non-resistant" scale insects.

Summary.—The data presented should only be considered as a start of the problem.

The density of the red scale population upon a lemon has no striking influence upon the kill obtained.

The proportion of resistant stages of the red scale does not determine the effectiveness of the fumigation but probably determines which insects will survive in an unsuccessful fumigation.

The type of concentration curve has no decided influence upon the kill providing there is a good distribution of gas

A low concentration built up and maintained and a quick high concentration rapidly leaking away gave similar results.

Under unfavorable conditions, satisfactory kills cannot be obtained by merely raising the concentration or increasing the time of exposure.

High temperature and low relative humidity favor a poor kill of "resistant" red scale.

In many cases, the insects are more difficult to kill where the temperature of the lemon is higher than that of the air.

Very low temperatures shortly following the fumigation will tend to reduce the kill.

Exposure of the insects to low concentrations of hydrocyanic acid before the fumigation may materially reduce the kill, have no influence upon it or actually increase the kill.

Under unfavorable conditions, the kill of "resistant" red scale is decidedly reduced whereas the kill of "non-resistant" red scale is influenced but slightly. Under favorable conditions, there is no significant differ-

ence between the kills of "resistant" and "non-resistant" red scale.

The main difference between "resistant" and "non-resistant" red scale is the influence, upon the results of a fumigation, of certain environmental conditions.

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THE MECHANISM OF ABSORPTION OF SODIUM FLUORIDE BY ROACHES

By GEORGE L. HOCKENYOS, *Springfield, Ill.*

Contribution No. 157 from Department of Entomology, University of Illinois.

ABSTRACT

A technique is described whereby individual roaches (*Periplaneta americana*, *Blatta orientalis*) are straitjacketed and the fluoride applied to various parts of the body. The data so obtained is supplemented by dipping tests. The evidence all indicates that sodium fluoride can be absorbed directly through the body integument of the insect, especially through the membranous areas of the body wall, such as the junction of the head and thorax and also the region of the coxae. The large area of absorption necessary to take up enough fluoride to kill the insect would indicate that in actual practice the roach must absorb some of the toxic material by licking it off the body appendages.

Few insecticides have so admirably filled a need as has sodium fluoride when used against roaches. For many years, it has been the standard remedy for household as well as commercial use. Its cheapness, ease of application, and effectiveness have led to its being given first place by many writers on their list of recommended materials for killing roaches. If scattered about where the roaches are sure to run, it may be depended upon to kill many of the pests; and by its recurrent use premises can be kept reasonably free from roaches.

The exact mechanism whereby the chemical kills the insect has not been carefully studied, but evidence from various sources indicates that it adheres to the antennae and tarsi when the roach runs over it and is then licked off in the cleaning process to which the insect subjects these parts. Some evidence, notably that of Shafer[1] indicates that the fluoride can be directly absorbed through the body integument after partially dissolving in the body exudations. With these facts in mind the following experimental work was performed to determine if possible the exact mechanism of absorption.

METHOD.—In all of the tests, only adult specimens of *Periplaneta americana* and *Blatta orientalis* were used.

In order to be able to hold the roaches so that they would not lick any part of the body or otherwise remove the applied materials, it became necessary to devise a type of individual cage, which is herein referred to as a straitjacket. This consisted of a piece of bronze fly screen, 1 inch by 3 inches, folded back on itself crosswise. A small piece of wood, ½-inch wide and ⅛-inch thick, was then inserted between the folded edges and the wire screen bent around it. This molded the strait-

[1]Shafer. Geo. D. 1915. Mich Tech. Bul. 15 Part III.

jacket to a size and shape well suited to hold a roach without injuring it or permitting it to move in any direction. The two sides of the straitjacket were held together by a rubber band. A pair of crucible tongs with thin blades were used to handle the insects. If they were caught across the thorax by this instrument, they could be transferred to the straitjacket and a rubber band slipped into place with a minimum of effort and no injury to the roach. In some cases the fluoride was applied to the roaches while held in the crucible tongs and they were then placed in the straitjackets, and in other cases they were first jacketed and then fluoride later applied Several control tests with both the Americana and the Orientalis roaches showed that roaches of both species could be held in the straitjackets for at least two days without injury, and if removed to jars by that time might be expected to live for several days longer.

Two samples of fluoride were used; one an ordinary crystaline sodium fluoride consisting of particles varying from 2 microns to 800 microns in diameter, and a second which was the same product ground in a ball mill and air floated so that all the particles were from 1 to 5 microns in size

EXPERIMENTAL.—In the first test, .5 grams of the very fine sodium fluoride was distributed as evenly as possible over the bottom of a 10-inch round glass container. Five specimens of *Periplaneta americana* were put into this jar one at a time and caused to run about over the fluoride for 30 seconds. Each was then placed in a separate small fruit jar and observed for twenty hours without any food being given. At the end of twelve hours, three roaches were dead, one nearly dead, and one in fair condition but showing injury In twenty hours, all were dead.

A similar experiment was conducted simultaneously, but using the ordinary sodium fluoride. In twelve hours, two roaches were nearly dead and three showed only a little injury. In twenty hours, two were dead, two nearly dead, and one but little injured.

In both tests, the roaches were examined carefully at the time they were removed from the large jar containing fluoride to the small observation jars. It was found that the finely ground fluoride had adhered much better than the coarser material and that both powders were adhering to the following parts: the palpi, the tarsi of all six legs, the tibia of the metathoracic legs, and in large amount to the last three abdominal segments on the ventral surface. The antennae held no noticeable amount of the fluoride, probably due to the fact that the roaches were running excitedly and so held the antennae up out of contact with the floor of the jar.

Two similar experiments were run as follows: In one 3-inch fruit jar was placed .1 gram of the very fine powdered fluoride and in another, .1 gram of the coarser material. Five *Blatta orientalis* were placed in each jar and allowed to remain there. In the case of the coarse powder, the insects seemed unaffected in twenty hours; and only one was dead and one sick in forty-four hours. In the case of the very fine powder, two of the five were very sick in twenty hours, and all were dead in forty-four hours.

The following experiments were conducted to determine the relative importance of the above-mentioned points of adhesion in the actual poisoning of the roach: Two American and three Oriental roaches had very fine sodium fluoride applied to the palps by means of a camel's hair brush. They were placed in a fruit jar and observed for forty-eight hours, at which time they were all seemingly normal, and the experiment was discontinued. Five Americana roaches had very fine sodium fluoride applied to all of their tarsi and were then placed in a jar for observation. In twenty-four hours, one was dead and four seemed unaffected. In thirty-two hours, two were dead, two nearly dead, and one seemingly uninjured.

Similarly five Oriental roaches were treated with very fine sodium fluoride on the metatarsi only. After seventy-two hours, they were all active and the experiment was discontinued. In another test, the coarse sodium fluoride was brushed on the antennae of five Oriental roaches, and they were placed in a fruit jar. Within a few minutes, all the roaches had drawn their antennae through their mouthparts in the familiar act of washing. At the end of twenty-four hours, they were all active, and in forty-four hours only one was seemingly sick. This one died in fifty-six hours, but the other four were active at the end of eighty hours.

The above experiment was repeated with the five roaches placed in individual jars. All were active at the end of fifty-six hours. A similar test with the very fine powder gave a similar result.

From the above experiments one concludes that the roach must lick a considerable area of his appendages before enough fluoride is taken through the mouth to produce death in a reasonably short time. These tests throw no light on the question of the absorption of the fluoride directly through the body integument. It seems extremely unlikely that there would be absorption through the tibia, so a study of the absorption through the antennae and the last segments of the abdomen was made as follows:

Five Americana roaches were placed in straitjackets with the head free and then hung upside down just over a saturated solution of sodium fluoride so that the antennae dipped into the solution but no other part of the insect touched it. They were left in this position for twelve hours and were all alive and uninjured at that time.

At the same time, two Americana roaches were jacketed as above and a paste of the very fine sodium fluoride with a little water was placed on their antennae. In twelve hours, they were released and found uninjured To determine if the roaches readily swallowed a solution of sodium fluoride, a saturated solution was made and two American roaches were jacketed and hung for five minutes in the solution with the head and mouthparts alone submerged When released from the jackets twelve hours later, they were quite active.

To determine whether or not absorption through the last abdominal segments was important, five Oriental roaches were jacketed with the last three abdominal segments free. These segments were then dipped in very fine fluoride dust and the insects left in the jackets for twelve hours. They were very active when released, though it was noticed that the powder adhered in large amounts around the anal opening.

These tests indicate that no one of the parts of the insect which normally come into contact with the fluoride are very important as places for the absorption of the fluoride.

The following tests were then run to determine if any other area of the body was capable of taking up enough fluoride to produce death: Five Oriental roaches were placed in jackets after a small amount of very fine fluoride had been placed behind both metacoxae. Twelve hours later, one roach was dead, two nearly dead, and two fairly lively except that their metathoracic legs were paralyzed

In a similar experiment using five American roaches, the sodium fluoride was dusted between all the thoracic legs. In twenty-four hours, all were dead. The chitin is quite thin and flexible around the point of junction of the legs and thoracic segments and this probably accounts for the effectiveness of fluoride placed on this area. A similar but smaller area exists between the head and thorax. Accordingly, five Oriental roaches were jacketed and very fine sodium fluoride was dusted on the dorsal side of the junction of the head and thorax, while the insect was held upside down to prevent any powder from falling down to the mouthparts. In twelve hours, three were dead, one nearly dead, and one fairly active. A similar experiment was performed, using American roaches and the coarser powder. When released twelve hours later, four roaches were quite sick and two, active. They were placed in separate

jars for further observation, and in another twelve hours two were dead and the other four, quite active. Twelve hours later the same condition prevailed, and the observations were discontinued. From these tests, it can be seen that the fluoride can be absorbed through the thinly chitinized areas in sufficient amount to cause death, and that the fine powder is more effective than the coarser material.

In the following tests, the question of absorption through the more heavily chitinized areas was considered.

Ten Oriental roaches were jacketed and the entire ventral side of the abdomen pressed lightly into very finely powdered fluoride. The insects were then set to one side for eighteen hours. At the end of this time, four were dead, three nearly dead, and three only slightly injured. It was noted that the degree of injury was nicely proportional to the amount of fluoride adhering to the abdomen. There was a large variation in the amount of material adhering. Care was taken not to allow any of the powder to get up to the lateral edge of the abdomen and so possibly into the spiracles. Following this, three Americana and two Oriental roaches were placed in straitjackets, and very fine sodium fluoride was dusted liberally over the ventral side of the abdomen while the insects were on their backs. After sixteen hours, one Americana and one Oriental were dead and two Americana and one Oriental, alive. After twenty-four hours, four were dead and one, alive Simultaneously, ten roaches were dusted over the entire dorsal side of the abdomen with very finely powdered fluoride, using a camel's hair brush and being particularly careful to apply it liberally to the abdominal spiracles. The insects were placed in separate jars and not placed in jackets. Eighteen hours later, nine were apparently unaffected and one, slightly affected. From the above tests, it can be seen that the spiracles are relatively unimportant as a point of entry for fluoride dusts, even though the dust is very finely powdered. The ventral side of the abdomen is seen to be much more permeable than the dorsal.

A series of tests were then run in which the roaches were dipped in saturated sodium fluoride and the solution allowed to dry on the insects, thus depositing the fluoride on the body integument. In the first test, five roaches, two Oriental and three American, were placed in straitjackets and the abdomen dipped for one minute in saturated sodium fluoride. Sixteen hours later, one Oriental was dead, one nearly dead, two Americana dead, and one in fair condition. Apparently enough fluoride had been absorbed to produce death by this method, but it does not show whether the absorption was through the spiracles or through the chitin of the body integument, or through both.

To determine this, a test was run as follows: Five Oriental roaches were jacketed and the abdomen dipped for one minute in saturated sodium fluoride. The insects were then rinsed quickly in cold water to remove the fluoride solution adhering to the body integument. Twenty-four hours later they were released from the jackets and found to be uninjured

A comparison of these three tests indicates that the absorption is largely through the body integument, and not through the spiracles, because the solution taken up by the spiracles would not be removed by a quick rinsing in water.

Since a previous test had shown that roaches hung with the head submerged for five minutes did not swallow enough fluoride solution to cause death, it was felt that the entire insect might be safely dipped in the solution Accordingly, eleven Oriental roaches were placed in a fruit jar and a saturated solution of sodium fluoride was poured over them They were allowed to swim in the solution for thirty seconds while the jar was gently rotated to assure frequent submersion. The solution was then drained off and the roaches allowed to crawl into a clean jar. In sixteen hours, all were dead.

This experiment was duplicated save that after draining off the fluoride solution the insects were quickly rinsed in water. In sixteen hours, one was dead and the other ten, quite active. This last experiment was repeated, and the results were identical in that one roach was dead and ten, apparently quite uninjured in sixteen hours.

In order that ample time might be allowed for penetration of the trachea by the solution, the above tests were repeated as follows: Fourteen Oriental roaches were caused to swim in saturated sodium fluoride for thirty seconds and then rinsed After twelve hours, one was dead and thirteen, apparently uninjured

Ten Oriental roaches were then placed in the same solution for two minutes, drained, and rinsed. In twelve hours two were dead and eight, unaffected. Then ten Orientals were kept in water for five minutes, drained, and rinsed. After twelve hours, all were apparently uninjured.

The above tests indicate very strongly that the fluoride solution kills the roaches by actual absorption through the body integument and not by penetration of the trachea. One possibility, however, is that the solution when it dries on the insect is thereby drawn into the trachea. To eliminate this possibility, the following tests were run: Five Oriental roaches were dipped twenty seconds in saturated sodium fluoride and then removed to a clean jar without rinsing. In fifteen hours, they were

all dead. Five Oriental roaches were then dipped for twenty seconds in a similar solution and quickly dried in a warm air blast. The drying process required about four minutes. In fifteen hours, they were all dead. Finally, five Oriental roaches were dipped in a similar solution, dried in the air blast, rinsed in water, and again dried in the air blast In fifteen hours, they were apparently normal and active.

These experiments would indicate that the trachea are not a factor in the absorption of a saturated sodium fluoride solution. There yet remains the possibility that the sodium fluoride acts merely as a dessicating agent and is not absorbed. The following experiments were conducted to determine this point. Twenty Oriental roaches were dipped thirty seconds in saturated sodium fluoride and allowed to dry without rinsing. In fifteen hours, all were dead. Ten Oriental roaches were treated as above, except that 5% sodium chloride was used in place of the saturated (about 4.5%) solution of sodium fluoride. In fifteen hours, two were dead and eight quite lively. Ten Oriental roaches were dipped thirty seconds in saturated sodium fluoride and then rinsed in water before setting aside. In fifteen hours, two were dead and eight entirely unaffected. Ten similar roaches were similarly treated, but 5% sodium chloride was used. In fifteen hours, three were dead and seven entirely unaffected. It should be noted at this point that in these above four tests the roaches were some that had been in the laboratory for two days and were not as vigorous, probably, as the roaches used in all the other tests of these experiments. Consequently, the death of two or three roaches in ten may be looked upon as largely accidental. The results of these tests suggest that the lethal action of the sodium fluoride is not shared by sodium chloride and so must be attributed to the action of the fluoride ion.

Finally, a previous experiment was repeated to determine if enough fluoride could be absorbed through the abdomen alone to insure early death.

Five Orientals were placed in straitjackets and the abdomen dipped in saturated sodium fluoride plus blood albumen. They were then dried in a warm air blast and set aside. In fifteen hours, three were nearly dead and two but little if at all injured. Five Oriental roaches, similarly treated but rinsed and again dried, were all in good condition after fifteen hours.

The first of these two tests shows that enough fluoride can probably be absorbed through the abdomen alone to insure death, since three of the roaches out of five probably would have died in another ten hours. Since even five minutes of partial submersion in saturated sodium

fluoride did not cause death if the excess were rinsed off, it was thought that the surface tension of the solution was probably too high to permit penetration of the spiracles. Accordingly, roaches of both the American and Oriental species were dipped for thirty seconds in ½% solutions of a sulfonated fish oil in water. This solution apparently drowned the roaches as they were quiet when removed from the solution and never recovered activity.

CONCLUSION.—Sodium fluoride can be absorbed in lethal amounts directly through the body integument of the American and Oriental roaches, especially in the areas of the body where the chitin is thin and flexible. The coefficient of absorption is apparently rather low; and, since the fluoride dust as ordinarily used does not come in contact with the most effective areas, it is not likely that direct absorption is of very great practical importance in roach control. Neither an extremely finely powdered sodium fluoride dust nor a saturated water solution was taken up by the tracheal system in sufficient quantity to cause death. Enough fluoride is not swallowed by the roach in washing the antennae to cause death, but if the tarsi are all covered with fluoride enough may be taken in by way of the mouth. Fluoride accumulating on the palps is apparently not sufficient to cause death. Very finely powdered sodium fluoride is much more efficiently absorbed than is a coarser product.

COMMON NAMES OF INSECTS APPROVED FOR GENERAL USE BY AMERICAN ECONOMIC ENTOMOLOGISTS

First Supplement to List Appearing in Volume 24, Pages 1273–1310

A list of 70 common names was submitted to the active members of the Association for consideration, with the understanding that a name be considered adopted when less than 20 per cent of the votes cast was in opposition. Of this number 26 received the necessary votes for adoption. This list is given below with the addition of one change from a name previously adopted and one additional name for *Diabrotica duodecimpunctata* Fab.

INSECTS LISTED BY SCIENTIFIC NAMES

Adelphocorus rapidus Say	Rapid plant bug
Anastrepha ludens Loew	Mexican fruit fly*
Aspidiotus hederae Vallot	Oleander scale
Brachyrhinus ovatus L.	Strawberry root weevil
Coccus pseudomagnoliarum Kuw.	Citricola scale
Coleophora pruniella Clem	Cherry case bearer
Diabrotica duodecimpunctata Fab	Spotted cucumber beetle Southern corn root worm
Euscepes batatae Waterh	West Indian sweetpotato weevil

*Changed from Orange maggot.

Haltica canadensis Gent	Prairie flea beetle
Lepidosaphes ficus Sign	Fig scale
Ludius inflatus Say	Dry land wireworm
Ludius pruininus noxius Hyslop	Great basin wireworm
Megalopyge opercularis S. & A.	Puss caterpillar
Mordwilkoja vagabunda Walsh	Poplar vagabond aphid
Nodonota puncticollis Say	Rose leaf beetle
Panchlora cubensis Sauss	Cuban cockroach
Passalus cornutus Fab	Horned passalus
Pediculoides ventricosus Newp	Straw itch mite
Pheletes californicus Mann	Sugar beet wireworm
Prionus californicus Mots	California prionus
Prociphilus imbricator Fitch	Beech blight aphid
Rhabdocnemis obscura Bdv	New Guinea sugarcane weevil
Rhizoecus terrestris News	Ground mealybug
Scutigerella immaculata Newp	Garden centipede
Solenopsis molesta Say	Thief ant
Taeniothrips gladioli M. & S.	Gladiolus thrips
Tarsonemus latus Bks	Broad mite
Typhlocyba pomaria McAtee.	White apple leafhopper

Insects Listed by Common Names

Beech blight aphid	Prociphilus imbricator Fitch
Broad mite	Tarsonemus latus Bks.
California prionus	Prionus californicus Mots.
Cherry case bearer	Coleophora pruniella Clem.
Citricola scale	Coccus pseudomagnoliarum Kuw.
Cuban cockroach	Panchlora cubensis Sauss.
Dry land wireworm	Ludius inflatus Say
Fig scale	Lepidosaphes ficus Sign.
Garden centipede	Scutigerella immaculata Newp.
Gladiolus thrips	Taeniothrips gladioli M. & S.
Great Basin wireworm	Ludius pruininus noxius Hyslop
Ground mealybug	Rhizoecus terrestris Newst.
Horned passalus	Passalus cornutus Fab.
Mexican fruit fly	Anastrepha ludens Loew
New Guinea sugarcane weevil	Rhabdocnemis obscura Bdv.
Oleander scale	Aspidiotus hederae Vallot
Poplar vagabond aphid	Mordwilkoja vagabunda Walsh
Prairie flea beetle	Haltica canadensis Gent.
Puss caterpillar	Megalopyge opercularis S. & A.
Rapid plant bug	Adelphocorus rapidus Say
Rose leaf beetle	Nodonota puncticollis Say
Southern corn root worm	Diabrotica duodecimpunctata Fab.
Strawberry root weevil	Brachyrhinus ovatus L.
Straw itch mite	Pediculoides ventricosus Newp.
Sugar beet wireworm	Pheletes californicus Mann.
Thief ant	Solenopsis molesta Say
West Indian sweetpotato weevil	Euscepes batatae Waterh.
White apple leafhopper	Typhlocyba pomaria McAtee.

Scientific Notes

Pyrethrum Solutions for Determining Insect Infestations on Golf Greens. During the course of experimental work on webworms infesting golf greens in the summer of 1933, it was observed that some of the caterpillars on golf greens reported injured by sod webworms were second instar cutworms. A survey of several injured greens revealed that around 50 per cent of the cases had no sod webworms. The survey was made by wetting down unit areas of the greens with a solution ((approximately .001% pyrethrins) of pyrethrum, which caused the insects secreted about the roots of the grass to come to the surface. All the cutworm infestations discovered in this way yielded to applications of poisoned bran bait, as proved by subsequent determination.

Ray Hutson, *Section of Entomology, Michigan State College, East Lansing, Michigan.*

Long-tailed Mealybug Abundant on Citrus. The long-tailed mealybug, *Pseudococcus longispinus* Targ., heretofore considered primarily as a greenhouse pest and as an occasional pest on ornamentals, has appeared in large numbers on citrus in Rivera, Los Angeles County, California.

This species of mealybug has been known to occur on citrus in the Rivera district for a number of years, but this is the first time that it has become sufficiently abundant to require special attention. It has been estimated that approximately two hundred acres are involved in the infestation.

The Australian ladybird beetle, *Cryptolaemus montrousieri* Muls., which has been used with great success as a predator on all other species of mealybug in this district, does not readily take to the long-tailed variety, thus necessitating the use of other control measures.

Consequently, tests were made to determine the effect of regular field practice fumigation and spraying on this pest. It was found that the customary grove fumigation of cyanide using a 16 cc schedule, which could be used as a combination treatment for other scale pests, gave excellent results.

The long-tailed mealybug is the least injurious of any of the citrus-infesting species, and even in the most heavily-infested groves there has been as yet no damage other than the presence of sooty mold fungus upon the leaves.

Don. W. Clancy, *Los Angeles County Insectary, Rivera, California.*

The European Corn Borer in Egypt, *Pyrausta nubilalis* Hbn. was first reported for Egypt by Herr A. Andres in his "Note sur un Nouveau Ravageur de Mais" published in the Bulletin of the Societé Entomologique d'Egypte in December, (1912), on some ears of corn purchased from a street vendor, probably in Alexandria, altho he fails to state definitely the location. He states, however,

> "Je ne dispose pas de suffisantes observations pour savoir si cette espèce se trouve assez rèpandue en Egypte pour causer des ravages importants."

Curiously enough, considering the unenviable notoriety which this insect has attained in other corn-growing countries—maize is one of the most important Egyptian cereal crops—when the writer came to Egypt a score of years after Andres' observation there was still insufficient evidence to base serious charges of damages by *Pyrausta*. In Storey's List of Egyptian Insects is recorded the capture of the species at Ma'adi,

a suburb of Cairo, and also as far south as Minia, in Upper Egypt, while specimens existed in the private collection of Mr. Alfieri, taken by him in Alexandria. In the collection of the Ministry of Agriculture at Cairo there are several specimens labeled "Feeding on Maize at Damietta (on the Mediterranean) in Aug. 1916. In 1925, F. C. Willcocks, in his monumental work on "The Insects and Related Pests of Egypt," reported:—

> "We have never received any inquiries concerning the European corn borer, and although I have kept a special look out for it at Gizeh and elsewhere. I have have never been able to fine a trace of it."

Intrigued by the lack of any record of actual damage in Egypt by this normally voracious insect and by its apparent failure to spread widely despite its long established residence in the country, the present writer has for the past year kept a close watch on corn from Giza south to Assouan, with the same results recorded by Willcocks. In July last Dr. H. Priesner, the Entomologist of the Ministry of Agriculture, mentioned that he had received a suspicious looking larva from corn near Alexandria and when bred out this proved to be *P. nubilalis*. The following month, Dr. I. Fahmy, one of Dr. Priesner's assistants, made the first report of any appreciable infestation, about 5%, on some maize near Damietta on the upper portions of the plants

ARTHUR H. ROSENFELD, *Ministry of Agriculture, Giza, Egypt.*

Otiorhynchids Oviposit Between Paper. The oviposition habits of the common, large, leaf-eating weevil of the West Indies, *Diaprepes abbreviatus* L., have long been known that eggs are laid between two leaves, or between the split tips of a single cane leaf. A few years ago, Dr. Herbert Osborn Jr. noted that, in captivity, the beetles preferred paper to leaves between which to oviposit. The writer has found that this preference is shown not only in captivity, but also in the field.

In a small citrus nursery at Isabela, P. R., in which each seedling tree was tied to a slender stake, he affixed strips of paper to the tops of dozen or more of these stakes with a clip, the strips being eight or ten inches long and two or three inches wide, wrapped at their middle around the stake so that the two long loose ends were opposite each other. To a very surprising extent, these paper flags were chosen by the female beetles for oviposition, the theoretical rate of preference being overwhelmingly in favor of the paper, if one considers the available amount of leaf surface as compared with that of the dozen paper flags on the stakes. The preference was shown not only by the larger *Diaprepes* weevils, but also by the smaller *Lachnopus curvipes* F., which at Isabela were feeding on and ovipositing between citrus leaves. Within the last few days, large numbers of the small green weevil, *Prepodes (Exophthalmodes) roseipes* Chev., have been held in captivity, and it is found that the female of this species also always chooses paper in preference to leaves between which to lay her eggs. Indeed, the preference is so general in all the species observed that it may occur in similar beetles found elsewhere than in the West Indies.

The economic application of the preference of Otiorhynchid beetles for oviposition in paper is possibly not as obvious and immediate as the more generally practised methods of control, but is none the less certain. An exceptionally effective adhesive is required to stick together two shiny citrus leaves so that they will remain in close adherence until after the hatching of the enclosed eggs. Such the beetles possess. It is so effective indeed that the emergence of the young grubs from hatching egg-masses is often delayed for several hours, or days, until a thin place in the ring of it

laid around the egg-mass by the female can be found. When used for ovipositing between two sheets of paper, it is so much more effective than is necessary that the just-hatched grubs can not emerge, but imprisoned within its celophane-like ring, dry up and die. In nature, they never attempt to burrow thru the leaf to escape from the egg-cluster, and under the artificial conditions of egg-clusters between paper, they do not attempt to burrow thru the paper. Thus, once the paper flags are in place, they form an automatic trap for the eggs of the beetles, not needing to be renewed until the paper itself becomes soft and weathered In the tropics, the traps remain effective for at least three months, using thin, tough wrapping paper.

GEORGE N. WOLCOTT, *Entomologist, Insular Experiment Station, Rio Piedras, P. R.*

Notes on Potato Insects in Iowa. While making a survey of potato insects, the author on June 12, 1933 collected considerable numbers of small greenish colored caterpillars which were mining the potato leaves and quite frequently entered the petioles. Since this type of injury as well as the general appearance of the larvae was known to be characteristic of the potato tuber moth (*Phthorimoea operculella* Zeller), it was provisionally considered as such. Later both adult and larval specimens were determined by Dr. Carl J. Heinrich of Washington as *P. operculella* Zeller. Apparently this represents the first record of the potato tuber moth in Iowa. The wide distribution of this pest in Iowa as evidenced by collecting records made during the current season indicates that it has been established in the state for a few years. Specimens have been taken from various points in the entire eastern half of the state. In a few instances growers have reported the occurrence of caterpillars in potatoes in storage. Considerable numbers of the larvae were found to be parasitized by an ichneumonid parasite.

The potato stalk borer (*Trichobaris trinotata* Say) caused severe damage to potatoes in some fields during the summer of 1933, ranking next to the potato leafhopper as an important potato pest. This insect is present each year but serious outbreaks are of a sporadic nature. According to reports published by Dr. C. P. Gillette widespread damage occurred in Iowa in 1890 and again in 1892. Webster reported that *T. trinotata* occurred quite commonly in the state in 1912–13. In certain fields at both Ames and Pleasant Valley, Iowa, where the degree of infestation was checked carefully this season (1933), more than seventy-five per cent of the plants were infested and approximately ten per cent of these gradually wilted and died in the early part of July.

Two species of mirids, *Chlamydatus associatus* (Uhler) and *Campyloma verbasci* (Meyer), were present in large numbers on potato plants throughout the early part of the summer. According to present records they have not been previously associated with this host in Iowa. Their relationship to the potato plant and the damage resulting from their feeding activities and egg punctures have not been definitely established. All stages, including the eggs, of both species have been obtained in large numbers from the potato plant.

The false chinch bug has occurred in destructive numbers in many parts of Iowa during the last two years (1932–33) and occasionally has been observed to cause some injury by feeding on potato foliage. Such injury may be attributable to the fact that the natural host plants of the false chinch bug growing adjacent to potato fields were destroyed either by drought conditions or in the process of cultivation.

H. D. TATE, *Iowa State College, Ames, Iowa.*

On the probable reason for the scarcity of the Southern corn stalk borer (*Diatraea crambidoides* Grote) in Southeastern Georgia. In the coastal plain of eastern Georgia observation of cornfields during four seasons (1930 to 1933, inclusive) has shown that *Diatraea crambidoides* Grote, though present each year, has occurred in very small numbers, probably averaging not more than one larva to several thousand corn stalks. Being rare, the insect was of no economic importance during the period mentioned, and it seemed evident that an important factor was holding this injurious species in check.

In the light of investigation it appeared unlikely that a climatic factor was responsible for the scarcity of borers in the field. During 1931, beginning with one-half dozen larvae collected during the last week of May, the insect passed through three complete generations and a partial fourth, and larvae entered hibernation in largest numbers between the middle and the last of September.

The hibernating larvae within corn stalks were placed in soil hibernation cages during the last week of September. Within a few weeks every one of these larvae was devoured by a very common carnivorous ant determined by W. M. Mann as *Solenopsis xyloni* McCook. Many subsequent observations on occurrence and abundance of this ant, especially in cornfields of the coastal plain, indicated that in all probability it was the most important factor in limiting the abundance of *D. crambidoides*.

This species' habit of hibernating in the larval stage within the corn stalks during the long interval from the last of September, or earlier, to the last of the following April or early May subjects the insect during most of this period to attack by the ants, as these are active during much of the season mentioned. The ants continually search over the cornfields for insects they are able to destroy, and it seems probable from the observations made that they discover and devour most of the hibernating larvae of *D. crambidoides*, or so large a percentage of them that injurious populations of the insect are built up but slowly during a succeeding growing season.

GEORGE W. BARBER. *United States Department of Agriculture, Bureau of Entomology*

Insects Attacking *Solanum sisymbriifolium* in eastern Georgia. *Solanum sisymbriifolium* Lam. is a member of the family Solanaceae and was introduced from tropical America into the Southern States. It is peculiar entomologically in the unusual association of insects attacking it, which include a principal insect enemy of tobacco and the most important injurious insect of tomato and of potato. This plant is described in the floras as an annual, but in some instances, at least, it is a biennial. It grows from 2 to 4 feet high, bearing abundant fruits which turn red upon ripening. The plant is "armed all over with bright yellow prickles," including the upper and lower surfaces of the leaves and the husks of the fruit. The plant appears in March or April, depending upon whether it springs from roots or seeds, and it grows luxuriantly until October, during which period it is suitable as food for the insects mentioned below. Often grown as an ornamental for the sake of its showy fruit, it also has a limited distribution along roadsides and other waste places. The insects attacking it include the following:

Leptinotarsa decemlineata (Say). The Colorado Potato Beetle.—In eastern Georgia potatoes are grown early in the season, being harvested in June, and by July these plants have wholly disappeared from the field. For a few weeks the beetles are found feeding upon alternative and less favoured food plants, doing frequent damage at

this time to tomatoes and eggplants as well as feeding during July on a number of wild hosts, before disappearing for the year. However, eggs and larvae of this insect are seen on few of these plants, the injury, for the most part, being done by the adults. Nevertheless, during 1932, it was observed that this insect passed through a complete life cycle on *S. sisymbriifolium*, and this condition seemed to indicate that this plant was rather more suitable as food for this insect than many others on which it had been recorded.

Heliothis virescens (Fab.). The Tobacco Budworm.—Larvae of *H. virescens* are found attacking the tender leaves and unripe or ripe fruit of *S. sisymbriifolium* throughout the season. Frequently they strip the younger leaves and devour all the fruit on individual plants, as was the case in 1932; in 1933 they were generally less abundant. However, this plant is suitable as food for the larvae over a period of 5 or 6 months; and, since it has been found that a generation of the insect occupies about a month, from five to six successive generations may be passed on this plant in a year. Tobacco is harvested and generally disappears from the field during June in nearby areas, while *S. sisymbriifolium* is available as larval food from the time the adults first emerge from hibernation in the spring until the insect begins hibernation in the fall.

Protoparce sexta Johanssen. The Tomato Worm.—Tomatoes are usually transplanted into the field in April in this section and grow until the middle or the last of July, or occasionally until the middle of August. However, the larvae of the tomato worm are often found as commonly, or even more abundantly, on *S. sisymbriifolium* as on tomatoes throughout this period, as well as during the period after midsummer, when tomatoes are becoming less abundant, and until they disappear from the field. Often plants are entirely stripped of leaves by the larvae of this insect; and, as in the case of *H. virescens*, this wild host not only is a satisfactory host plant during periods when the cultivated hosts are wanting, but it provides an uninterrupted source of food from the time the insects emerge from hibernation until they begin hibernation again.

The long period occupied in growth by this plant, covering the whole of the growing season, permits *S. sisymbriifolium* to serve as a host to which the insects mentioned above may turn during seasons when their preferred cultivated food plants are wanting in the field, and on which, to a degree, their numbers may be saved from depletion because of lack of desirable food. This plant, therefore, occupies an important place in the economic agriculture of eastern Georgia by helping to maintain a stock of three important injurious insects.

GEO. W. BARBER, *U. S. Department of Agriculture, Bureau of Entomology, Savannah, Ga.*

A Flotation method for determining abundance of Potato Flea Beetle Larvae. It was important during investigations on the control of the potato flea beetle (*Epitrix cucumeris* Harris) to determine the number of larvae and pupae per hill of potatoes. The soil inhabiting forms of this insect are very delicate, soft-bodied and easily damaged by the ordinary methods of screening[1] and washing[2].

[1]Lane, M. C. 1928—A Soil Sifter for Subterranean Insect Investigations. Jour. Econ. Ent. Vol. 21—No. 6.

[2]Shirck, F. H. 1930—Soil Washing Device for Use in Wire Worm Investigations. Jour. Econ. Ent. Vol. 23—No. 6.

The method found most satisfactory was a system of flotation in which the larvae and pupae were floated out by agitating the soil from the potato hill with water. Shallow galvanized pans, 24 inches in diameter and 8 inches deep, were used as they gave an area large enough to reduce the thickness of the soil on the bottom to less than an inch. At first solutions of sodium chloride were tried but it was found that thorough agitation with water brought all of the forms to the surface. The settling process of several minutes eliminated clogging of the screens with mud when the liquid was poured off from the sample.

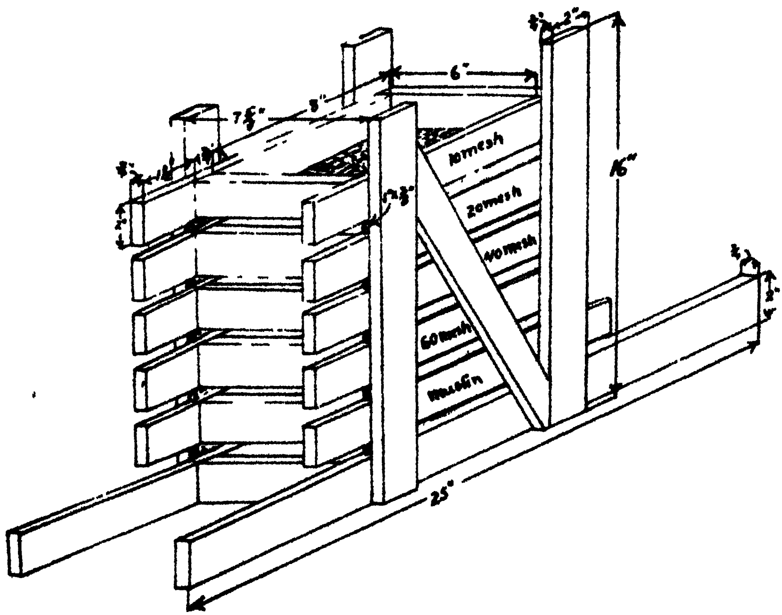

FIG. 110.—Drawing showing construction of screens used in collecting larval and pupal forms obtained by flotation.

The screens used in collecting the larvae were made from brass cloth. The largest mesh was the 10 to the inch mesh which removed all of the sticks and trash. This was followed by a 20, 40 and a 60 mesh screen. The pupae and some larvae were caught in the 20 mesh, but most of the larvae were taken in the 40 mesh screen. For a time a muslin filter was used to make sure that all the forms required were being taken in the screens. It was soon found that this stage was not necessary.

Each screen was mounted on a wooden frame. These frames were made from pine 2 inches wide and three-fourths inch thick. Their shape was rectangular, 6" x 8" with a 1.5" projection on one end, to facilitate handling and withdrawing from the rack holding the screens. Each screen was a separate unit and could be withdrawn without disturbing the others. The drawing illustrates the arrangement and the construction of the screen frame and rack.

The rack holding the screen frames was made of 2" x ¾" material fastened together with screws. It consisted of 4 upright pieces 16" high fastened to a base of 2 pieces 25" long, sufficient to reach across a flotation pan. The uprights were placed

far enough apart to allow the screens to be inserted with ease, 7.6" wide and 9.5" long. The 1.5" projection from each screen extended so that it could be easily grasped for removal. The slides for each screen were made from 1 by ⅜ inch material Each piece was 9.5" long and a pair of them were firmly attached to the four uprights. The screen rested on the slides. The whole frame was strongly braced with two pieces fitted into the sides.

The liquid from the pans was poured through the screens A gentle washing with a spray cleared away the mud and sediment. Each screen was removed to make the counts. It was found that a large rectangular white enamel pan, with clean water in the bottom, aided in counting and increased the efficiency of the method. The bottom of the screen was immersed in the shallow water and the larvae and pupae were readily identified.

This method has been used successfully in 1931 and '32, in determining the number of flea beetle larvae and pupae in the potato fields of Northeastern Colorado. It has been important to know the periods of greatest abundance in timing the application of dust and spray in the control of larval injury on the tubers.

LESLIE B. DANIELS, *Colorado Agricultural College.*

Winter Mortality of the Camphor scale and Dictyosperma scale in 1933 at New Orleans, La. In a previous note[1] on the winter mortality of three of the most injurious insects in New Orleans it was reported that, following a freeze in January, 1924, when the Weather Bureau recorded minimum temperatures of 26° and 19° F. on two successive days, about 16 per cent of the overwintering females of the camphor scale, *Pseudaonidia duplex* (Ckll.), were killed by the low temperatures. The mortality of the dictyosperma scale, *Chrysomphalus dictyospermi* (Morg.), was about 99.6 per cent and of the Florida red scale, *Chrysomphalus aonidum* (L.), about 99.9 per cent. The mortality of the camphor scale experienced in 1924 had little effect upon intensity of the subsequent infestation. However, the Florida red scale apparently failed to survive except in some greenhouses, and since that time has never become a pest of any importance in New Orleans. A few dictyosperma scales survived in some locations and there has since been a gradual increase in the infestation in this district.

On February 9, 1933, a minimum temperature of 20° F was recorded by the Weather Bureau, and at our laboratory on the outskirts of the city a thermograph registered 17.5° F. The temperature was below the freezing point for about 18 hours. For several weeks previous to this time the temperatures had been generally above the normal. It was thought that a comparison of the mortality experienced this year with that found in 1924 would be of interest, although, owing to the scarcity of the Florida red scale, such a comparison could be made only for the camphor and dictyosperma scales. In addition, any information on the susceptibility of the camphor scale to low temperatures is of especial value because of its bearing upon the possible limits of distribution of this insect. Up to this time no infestations have been discovered north of Louisiana, and the scale is largely confined to the central and southern parts of the State.

[1]1924. Catchings, Thos. F., and Whitcomb, W. D. Notes on winter mortality of the three coccids, *Pseudaonidia duplex* (Ckll.), *Chrysomphalus aonidum* (Linn.), and *Chrysomphalus dictyospermi* (Morg.), at New Orleans, Louisiana. Jour. Econ. Ent. 17:604–606.

When the prediction of low temperatures was received February 8th, camphor twigs heavily infested with the camphor scale were taken from the field and brought to the laboratory for counts. The camphor scale passes the winter in the adult stage and the dead immature scales as well as dead adults of the older broods were classified separately and eliminated from further consideration. On March 2nd, another count was made from uninjured twigs to determine the mortality caused by low temperatures of February 9th. By this time a number of young had emerged from beneath the scale coverings. These have also been disregarded in obtaining the mortality shown in the last column of Table 1.

TABLE 1. DISTRIBUTION OF STAGES AND MORTALITY

Date counted	Living scales in each stage White	Pink	Gravid	Reproducing	First instar (new brood)	Overwintering scales Counted	Dead
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Number*	*Per cent*
February 8..	1	2	3	95	0	1,966	10.0
March 2....	0	1	2	58	39	2,070	47.0

In order to determine what part of this increase of 37 per cent in mortality was caused by freezing the results were compared with changes in natural mortality found in counts made at weekly intervals during 1926, 1927, and 1928. It was found that in no two of the four years was the population distribution identical and that the changes that occurred were due partly to weather conditions. The counts made February 8, 1933, represented the time when the maximum percentage of scales was reproducing. In no other year was the peak so high as 95 per cent. Sometimes the proportion reproducing rose to a sharp peak, and in 1926 there was a flat-topped curve caused by low temperatures which prevented the young from emerging.

Because of the different rates of change of the distribution of stages, the mortality trends which existed during the years in question were estimated in three ways: (1) by a comparison of the mortality at the peak of production with that 22 days later; (2) by a comparison of the mortality at the peak of production with that at the time 39 per cent of the population were in the first instar; and (3) by a comparison of the mortality at the time 39 per cent of the population were in the first instar with that observed 22 days earlier.

It was found that whatever was taken as the proper interval to use in estimating the normal trend in mortality between the freeze and the time of counting in 1933, the maximum change for the period in 1926, 1927, and 1928 was +7 per cent and the minimum 0 per cent. It appears therefore that between 30 and 37 per cent of the overwintering scales on wood uninjured by the freeze were killed by the low temperatures of February 9, 1933. The actual mortality on camphor trees was considerably higher than this because many of the younger twigs were killed. Since the active crawler has a tendency to migrate to the younger growth, a large proportion of the living scales were on wood that was frozen.

No field counts were made on the dictyosperma scale previous to the freeze, but on March 30 a number of *Podocarpus* leaves heavily infested with this scale were examined to determine the proportion of dead insects. It was found that out of 2,247 scales, 2,167, or 96.4 per cent, were dead. All of the immature stages were dead with the exception of 23 of the first instar, which had evidently emerged since the freeze and were not considered in calculating the above percentage. A number

of the living adults were reproducing, and eggs and crawlers were found beneath the coverings. In weekly seasonal-history counts made in 1927, we found that the mortality ranged between 30 and 40 per cent during the winter. While enough dictyosperma scales have been killed to reduce the infestation greatly, it is probable that no infestations have been eradicated. The insect is a rapid breeder, as many as six generations having been reared in the laboratory in one year, and the infestations may be restored to their original status in a short time

A. W. Cressman and L. T. Kessels, *U. S. Bureau of Entomology, New Orleans, La.*

CONFERENCE OF CONNECTICUT ENTOMOLOGISTS

The tenth annual conference of entomologists working in Connecticut was held in the Assembly Room at the Agricultural Experiment Station, New Haven, on Friday October 27, 1933. Professor J. A. Manter was elected chairman and 60 were present. Luncheon was served at the Station. Director Slate, Dr. Glasgow and Mr. Worthley were unable to be present. Mr. Worthley sent a paper that was read by Mr. Johnson. In other respects the following program was carried out:

Greeting, Director William L. Slate, New Haven.

Entomological Features of the Season of 1933, Dr. W. E. Britton, New Haven.

Recent Termite Depredations in Connecticut, M. P. Zappe, New Haven.

Insect Work in Civilian Conservation Corps Camps in Connecticut, G. H. Plumb, New Haven.

Recent Developments on the Gipsy Moth Project, A. F. Burgess, Greenfield, Mass.

The Status of the Japanese Beetle in the United States in 1933, L. H. Worthley, Harrisburg, Pa.

The Japanese Beetle and the European Corn Borer in Connecticut in 1933, J. P. Johnson, Shelton.

Notes on the White Birch Leaf Miner, *Phyllotoma nemorata* in New York, Dr. R. D. Glasgow, Albany, N. Y.

Inspection of Special Exhibits and of the Department of Entomology.

The Strength of Caterpillars, Prof. J. A. Manter, Storrs.

Round Table Discussion on Collecting Lepidoptera, John V. Schaffner, Melrose Highlands, Mass.; Otto H. Schroeter, Union, Conn.

New Angles in Relation to Shade Tree Pests, Dr. E. P. Felt, Stamford.

The Control of Fleas in Households, B. H Walden, New Haven.

Studies on the Potato Flea Beetle, Neely Turner, New Haven.

Experience with Lead Arsenate Substitutes, Dr. Philip Garman, New Haven.

Sprays for the Control of the European Pine Shoot Moth, Dr. R. B. Friend, New Haven.

The following were present: I. L. Bailey, Greenfield, Mass.; S. C. Ball, R. M. Bond, R. C. Botsford, W. T. Brigham, W. E. Britton, New Haven; R. C. Brown, Melrose Highlands, Mass.; A. F. Burgess, Greenfield, Mass.; T. M. Cannon, Springfield, Mass.; C. W. Collins, Melrose Highlands, Mass.; O. B. Cooke, Danielson; R. G. Cooper, South Manchester; S. S. Crossman, Greenfield, Mass.; R. M. DeCoursey, Storrs; L. A. DeVaux, Shelton; H. C. Engelhardt, New Haven; E. P. Felt, Stamford, W. O. Filley, H. J. Fisher, R. B. Friend, New Haven; C. W. Frink, Willimantic; W. C. Hall, Storrs; P. Hansling, Jr., R. C. Hansling, Hartford; H. A. Hulse, P. Garman, New Haven; G. H. Geissler, Vincennes, Ind.; J. P. Johnson, Shelton; J. W. Kelley,

II, Storrs; R. E. Kimport, New Haven; D. S. Lacroix, Amherst, Mass.; J. W. Longo, Danielson; H. J. MacAloney, New Haven; J. A. Manter, Storrs; J. J. McDonald, Bridgeport; J. A. McEvoy, Putnam; B. W. McFarland, New Haven; W. J. Nalewaik, Bridgeport; D. L. Parker, Melrose Highlands, Mass.; T. Parr, Clinton; G. H. Plumb, New Haven; J. E. Riley, Jr., New Haven; A. A. Saunders, Fairfield; J. V. Schaffner, Melrose Highlands, Mass.; J. C. Schread, New Haven; O. H. Schroeter, New London; C. E. Shepard, Mount Carmel; R. A. Spencer, Bloomfield; G. R. Smith, New Haven; L. R. Stark, Greenfield, Mass.; G. A. Thompson, Jr., Kingston, R. I.; J. F. Townsend, H. H. Townshend, N. Turner, New Haven; A. M. Vance, Arlington, Mass.; B. H. Walden, New Haven; T. R. Ward, New London; A. J. Warren, A. S. West, Jr., New Haven; M. P. Zappe, New Haven.

PROPOSALS REGARDING THE JOURNAL OF ECONOMIC ENTOMOLOGY

The Journal of Economic Entomology has occupied an important place in the field of economic entomology since its establishment 26 years ago. Those who have had to do with the management, and particularly the man who has been its editor from the beginning, E. Porter Felt, deserve the highest praise for their unselfish devotion to the Journal's interests. The recent volumes of the Journal are larger by threefold than the earlier volumes; membership in the organization has greatly increased; and the field covered by articles in the Journal has become greatly enlarged and diversified. With such changed conditions it naturally follows that a discussion of possible changes in the Journal itself might be in order.

The undersigned have been appointed by President Hinds as a committee to consider the publication policy of the Journal of Economic Entomology. In order to get something tangible before the membership, it has been decided to submit certain definite proposals to the active membership of the Association for decision. The committee will attempt to determine, with due consideration to the results of the canvass, to what extent the proposals receiving favorable vote may be carried out in practice. Recommendations will then be presented before a regular winter meeting of the Association for final action.

A post card will be sent to the active members of the Association, at about the time of the appearance of this notice in the Journal, on which an expression of approval or disapproval is asked on each of the following proposals. Please return promptly the self-addressed reply card

(1) Typography.—The printing of more material per page is recommended by the use of solid instead of leaded type. With the same 10-point type the lines per page would be increased from 41, as at present, to 53, as in the Journal of Agricultural Research. Abstracts, Scientific and Current notes should be set in 8-point solid type, such as quotations in the Journal of Agricultural Research. Tabular material in the Journal could be improved and condensed by the use of 6-point or occasionally 8-point type. Photographs should appear only for the purpose of a better understanding of the paper.

(2) Reprints.—25 reprints of each paper shall be furnished on request to the authors without charge, and additional reprints shall be supplied at cost. Income from the sale of additional reprints on a cost basis should be credited to the Journal account and not included with dues in the Association account, as at present.

(3) Financial Policy.—The entire income from the Journal shall be devoted to its publication and administration, and none shall be diverted to the so-called "Perma-

nent Fund." During the last three years $1650 has been transferred to the Permanent Fund from the Journal account, and $2650 from the Association account. The fund is now large enough to care for emergencies and it is believed further additions should be restricted to surplus income from dues in the Association account.

(4) LENGTH OF PAPERS.—The present restriction on the length of articles in the Journal shall be changed from a paper basis to a member basis. The following plan is believed to be equitable for such restrictions. Each member is to be allowed a total of 8 pages annually, exclusive of abstracts. In cases of joint authorship, the addition of 1 or more members as authors of a given paper shall add 4 pages to the free page allotment of that paper, which addition shall be assessed equally against the annual free allotment of such additional member-authors. If a member does not publish in one year or uses less than ½ of his free page allotment, he may use 12 pages the following year; if he does not publish for 2 years or more, or has used less than ⅓ of his free page allotment over this period, he may use 16 pages without extra charge. The charge per additional page shall be at the cost price to the Association. Free publication as outlined shall be restricted to members only, except that an annual total of 150 pages may be reserved for especially meritorious papers presented by non-members or by members in excess of their privileged allotment, to be used at the discretion of the Editorial Board.

During the last three years 23% of the authors (or joint authors) publishing in the Journal were not listed as members, while about ⅓ of the papers exceeded the present 6 page limit. Of authors who were members, 53% published only once in the Journal in three years, 27% twice, 11% three times, 9% published from four to nine times and wrote ¼ of all of the papers by members, a disproportionate share of the available free space in the absence of selection based on merit.

(5) EDITORIAL POLICY.—The editorial policy of the Journal shall provide for the critical review of contributed articles before their acceptance for publication, as is customary in other scientific journals. Entomologists in certain institutions have the advantage of critical examination of the manuscripts before publication, while other contributors are not so safeguarded. It is believed that the following policy would benefit the author, raise the standard of the Journal, and conserve space without unduly burdening the editor or any one member of the Editorial Board. At the present time contributed articles not appearing in the proceedings of any meeting occupy about ⅓ of the space devoted to papers in the Journal. If the next section is adopted, all papers would be "contributed articles."

(a) *Instructions to Authors.*—The Journal will accept manuscripts bearing on economic entomology. Authors must observe the utmost brevity consistent with clarity of presentation. Manuscripts shall be addressed to specialists in the particular fields rather than to the general reader. Extensive reviews of the literature ordinarily should be omitted. When well-known or previously published procedures have been followed in the experimental work, they shall be designated or referred to only. Since original data are often of more lasting importance than the summaries, authors should be urged to include the original numerical data of most papers in one or two compact tables for reference. Papers shall contain a few introductory sentences stating the significance and main objectives of the investigation, and at the end a brief summary of the results obtained. To facilitate action by the Editorial Board, it is desirable

that each manuscript be accompanied by a statement that it has been read critically and approved by one or more persons (named) familiar with the subject. Two copies of the papers shall be submitted to the Editor, who will record on them the date of receipt for publication.

(b) *Editorial Board.*—The Journal shall be managed by an editor, business manager, and an editorial board of 12 members selected by the Executive Committee and representing different subdivisions of entomology, such as general entomology, insect biology, ecology, chemical and cultural control, physiology and toxicology, biological control, medical and veterinary, apiculture, plant quarantine and inspection, and extension.

Members of this board shall serve for 3 years, with 4 new members selected each year. This board shall supersede the present Advisory Board and name the editor and business manager of the Journal.

(c) *Method of Reviewing.*—All contributed papers shall be passed by 2 or more members of the Editorial Board before acceptance for publication. The editor will refer manuscripts to members of the board representing the field or related field of the paper. After reading the manuscript, if each believes that the paper has sufficient review for submission, he will return the manuscript to the editor with his own comments. If a further review is believed necessary, he will submit the paper to one or more experts outside of the Editorial Board. Any criticisms by such reviewers that seem valid to the board member will be relayed with additional comments directly to the author for his consideration. Reviewing is intended to insure scientific accuracy and brevity and not a standardized style of writing. Authors shall be notified of the decision of the board within 6 weeks of the receipt of the paper by the editor. If for any reason a paper is considered unsuitable for publication, the author or a board member may appeal to the board as a whole for decision by majority vote.

(6) PUBLICATION OF PROCEEDINGS.—Except for the President's address, the papers listed in the program of all national, sectional, and branch meetings shall be published in the proceedings in abstract only, as is the custom of the American Phytopathological Society and several other scientific organizations. In the case of papers which are to be submitted for publication in the Journal, the abstract shall be restricted to 300 words. If the paper is not to be published in the Journal, 500 words may be used in the abstract. It is proposed that the abstracts be published whether the papers are read or not, and that the proceedings, including minutes and abstracts of papers, be condensed and appear in the first issue of the Journal after the meeting. Despite the small percentage of the membership which is able to attend the meetings, over 60% of the Journal is devoted at present to publishing proceedings. The adoption of the above plan would equalize the opportunity for publication by putting all papers and all members on the same footing; would permit those who could not attend to appear in the proceedings in abstract form and to follow the entire session without the omissions caused by publication elsewhere; and would facilitate the preparation and approval for publication of current work in abstract form which in the final paper might be delayed.

(7) MONTHLY ISSUE OF JOURNAL.—Because of the large size of the present numbers, and to provide for inevitable expansion and more prompt publication of articles, consideration should be given to the possibility of issuing the Journal monthly.

H. J. QUAYLE
C. L. METCALF *Committee*
A. F. BURGESS

COMMENTS ON PROPOSALS REGARDING THE JOURNAL OF ECONOMIC ENTOMOLOGY

It is to be hoped there will be a general response to the request by a special committee for opinions in regard to the future policy of the Journal. It is obviously desirable that these opinions be based upon the fullest possible information and that they be formulated with some recognition of the possible effects if one or more are adopted. It is with this in mind that the following statements are made, the numerals referring to the numbered paragraphs in the proposals submitted by the committee.

1. This was submitted to a large proportion of the active members in 1929, and the sentiment being approximately fifty-fifty no change was made. The actual saving in cost is approximately ten per cent.

2. Were the Journal to furnish reprints to authors, it would mean the use of funds otherwise available for printed matter It might cost $500 annually. Reprint income has always been credited to the Journal.

3. The amount diverted to the permanent fund has not been large in proportion to entire expenditures. The desirability of continuing this depends on the purpose of the permanent fund.

4. Increased length of papers presumably means more copy submitted, unless there is a rigid restriction in some other direction. A strictly impartial member allotment would mean one page annually per member. Does the recommendation as to actual cost for excess matter refer to composition charges or entire cost? Present charges are intermediate. The percentage data on authorship are misleading even if correct. They should be interpreted since membership papers appear in the main association sessions and those of sections or branches. There are leaders in all of these divisions, some with broad interests. It is hardly feasible to limit such men to one branch or one section. This is the explanation in large measure of a number of papers by individual members.

5. The editorial policy suggested evidently contemplates a rigid restriction to more technical papers. The Journal is dependent for support upon its subscribers, and they, it should be remembered, represent very divergent interests. Subscription rates of current technical publications indicate a probable trebling of subscription rates if the Journal was limited to technical papers and the volume of matter remains about the same. The changes indicated in sub-paragraphs b and c would eventually mean increased expenditures, and in the case of the latter considerable delay in publication. Authors connected with the Federal Bureau of Entomology, where a method of review is in force, have great difficulty in getting their manuscripts through in time to take their places in the Proceedings, even if the latter are held open to the latest possible date. A question may be raised as to the advisability of publishing the proceedings in abstract under present conditions.

6. This practically means a technical publication and may easily result in greatly increased costs.

7. Monthly issues do not necessarily mean more prompt publication. This latter can be obtained only by increasing the size of the Journal or establishing such rigid restrictions as to cut down greatly the amount of matter submitted for publication.

E. P. Felt

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER 1933

A committee on the policy of the Journal is seeking information in relation to certain proposals. These are published on a preceding page. All have advantages and disadvantages. It is hoped that the considerations both for and against these propositions will be carefully weighed, since the ultimate effect may be fully as important as any immediate gain or loss. The Journal, as the official organ of the Association, has endeavored to serve its large and varied membership. It has been a self-sustaining activity and depended entirely or almost entirely upon a very modest subscription rate. A reduction in the number of subscribers would mean either a raising of the subscription rate or curtailment of the amount of printed matter. The restriction of publication to the more technical papers, desirable though this may be from certain viewpoints, may have unanticipated effects. The probabilities are that some changes must be made in the not distant future. The problem is to determine what changes may be practicable.

The program, printed elsewhere in this issue, should be given a more than careful examination. The Secretary made an appeal for comprehensive and informative abstracts. Some papers are accompanied by these and others have none. It is quite possible that in the latter cases the authors found themselves unable to formulate a summary prior to the writing of the paper and that the preparation of this was unavoidably delayed owing to numerous other matters claiming attention. Papers of

both types will be presented at the Boston meeting, and it follows that those who have gone to the trouble of preparing extensive abstracts can take advantage of this information in the program and limit, if they so desire, the presentation of the paper to the more salient and important points and thus possibly leave some time for discussion. Those who have not submitted abstracts cannot profit, if there is profit, by such an arrangement. Those attending the meetings will have an excellent opportunity to decide as to whether the printing of extensive abstracts in the program is advisable or not Aside from the presentation of scientific data, this meeting will somewhat unwittingly give an actual demonstration as to the relative value of one system as compared with the other. It is hoped that those attending will give this phase of the matter close attention, with the possibility in mind of offering constructive criticism.

Obituary

Shinkai Inokichi Kuwana[1]

The eminent Japanese entomologist, Shinkai Inokichi Kuwana, died of heart failure in Tokyo, Japan, July 14, 1933. His loss to the natural sciences is great and he is mourned by entomologists and biologists the world over. Not only in his native land was he recognized as a great student of insects, but also in the United States where he lived six years and where he procured his higher educational training and made many warm personal friends.

He was born in the village of Kurotsuchi-mura, Chikugo-gun, Fukuoka-Ken, Island of Kiushiu, in southern Japan, on May 17, 1872.[2] Here his boyhood was spent on a farm. From his brother, J. K. Kuwana[3], we learn that in early youth he was much interested in natural history. His desire for educational advancement is indicated by the fact that when he was but sixteen years old he was a school teacher in his own village. As a means of preparing for advanced studies, he went to Hawaii at the age of eighteen to learn the English language. He re-

[1]Howard, L. O., A history of applied entomology. Smithsonian Institution, Washington, D. C., pp. 341, 343, 345, 346; pl. 31, fig. 2, 1930.

[2]Registered simply from Fuknoka, Japan, as the place of birth and May 17, 1872 as the date. This and other information concerning his connection with Stanford University were kindly furnished by the registrar, J. P. Mitchell under date of Sept. 25, 1933.

[3]J. K. Kuwana, Los Angeles, California, kindly furnished many facts concerning the intimate life of Mr. Kuwana as well as the photograph reproduced herewith.

mained there three years during part of which time he acted as an interpreter on a sugar plantation.

In 1895 he came to the United States and entered Cornell University, Ithaca, New York, registering from Higashi-Karuizawa, Aoki-Cho, Yokohama, Japan. He remained there until 1897. Dr. J. G. Needham, who kindly furnished this bit of information states: "I was here during the last year of his residence and knew him, but not intimately, as a quiet, careful student; and I have corresponded with him intermittently ever since and have exchanged papers with him."

He entered Stanford University, Palo Alto, California, as a special student in 1897. He graduated with the A. B. degree in entomology in 1899. In September of that year he was admitted as a graduate student and received the A. M. degree in the Department of Zoology in 1901 His master's thesis was entitled "Coccidae (scale insects) of Japan." During this period he was one of a group of students studying entomology under Vernon L. Kellogg, practially every one of whom have since become leaders in his chosen specialty. As a student Kuwana became interested in the Mallophaga and certain families of Homoptera, especially the Coccidae, Aleyrodidae, and Aphididae

During this period in California he also made many contacts with local entomologists and learned something concerning the importance and value of plant quarantine and methods used in combating injurious insects in California

Following his return to his native Japan, he was appointed a member of the Imperial Central Agricultural Experiment Station at Nishigahara, Tokyo, in 1909 and was made director of the newly organized Imperial Plant Quarantine Station at Yokohama in 1914 and thus became the first and leading authority on plant quarantine in his own country. During the years that have followed he not only supervised the plant quarantine work but has also acted as chief entomologist for the Ministry of Agriculture and Forestry and of late years maintained headquarters at Tokyo, where he has occupied a strategic position in relation to all foreign entomologists visiting Japan.

Kuwana was nominated as a foreign member of the American Association of Economic Entomologists by Dr. L. O. Howard in December 1909 and was duly elected and had continued as such to the time of his death.

During the summer of 1919 he again visited the United States and made a general survey of the entomological activities in this country and formed many new acquaintances.

In recognition of his valuable services, high state honors were conferred upon him by the Emperor of Japan. He is survived by his wife

S. I. Kuwana and Mrs. Kuwana
Photograph loaned by J. K. Kuwana.

and an only son, Juichi Kuwana, of the Kyoto Imperial Sericultural College. He was buried in Tokyo.

He began publishing on insects in 1901 and has continued to produce worthy articles throughout his busy life. Although many of his papers are printed in Japanese nearly all of his technical contributions are in English. He came to be a leading world authority on the Coccidae of Japan and his papers are of an excellent order. Among his more important contributions are the following:

COCCIDAE

1901. Notes on new and little known California Coccidae. Proc. California Acad. Sci. (3) vol. 2 Zool. p. 399-408, 2 pls.

1902. Coccidae of Japan [I]. Proc. California Acad. Sci. (3) Zool. p. 43-98, 7 pls.

—— Coccidae from the Galapagos Islands. Jour. New York Ent. Soc. vol. 10 p. 28-33, 2 pls.

1904. The San Jose scale in Japan. Imperial Agr. Exp. Station Japan, Tokyo. 33 pp. 8 pls. (2 colored).

1907. Coccidae of Japan [II]. Imperial Agr. Exp. Station Japan, Tokyo. vol. 1 No. 2, p 177-231, 9 pls.

1909. Coccidae of Japan III. First supplemental list of Japanese Coccidae, or scale insects, with descriptions of eight new species Jour. New York Ent. Soc. vol. 17 p. 150 158, 3 pls.

—— Coccidae of Japan IV. A list of Coccidae from the Bonin Islands (Ogasawara-Jima), Japan. Jour. New York Ent. Soc. vol. 17 p. 158-164, 3 pls.

1914. Coccidae of Japan. P. C. Jour. Ent. & Zool. vol. 6 p. 1-8, 3 pls.

1916. Some new scale insects of Japan. Annot. Zool. Japanenses. vol. 9 p. 145-151, 1 pl.

1917. A check list of the Japanese Coccidae. Coll. Essays for Mr. Yasuchi Nawa, Yokohama, Japan. 19 p. Oct. 8.

1922. Studies of Japanese Monophlebinae. I, The genus *Warajicoccus*. Bul. Imperial Plant Quar. Sta. No. 1, 58 pp. 12 pls. (5 colored). II, The genus *Icerya*, No. 2, 43 p. 14 pls. (1 colored.)

1923. Descriptions and biology of new or little-known coccids from Japan. Bul. Imperial Plant Quar. Sta. Bul. 3, p. 1-65, pls. i-xiv.

—— The Chinese white-wax scale, *Ericerus pela* Chavannes. Philippine Jour. Sci. vol. 22 p. 393-405, 2 pls.

1925. The diaspine Coccidae of Japan I. *Genera Poliaspis, Ischnaspis*, and *Parlatoria*. Dept. Agr. & Comm. Bur. Agr. Injurious Insects & Pest Ser. No. 14, 18 p. 3 pls.

—— The diaspine Coccidae of Japan II. The genus *Lepidosaphes*. Dept. Finance, Japan Imperial Plant Quar. Service. Rev. Bur. Tech. Bul. 2, 42 p. 11 pls.

—— The diaspine Coccidae of Japan III. The genus *Fiorina*. Dept. Finance, Japan Imperial Plant Quar. Service. Rev. Bur. Tech. Bul. 3, 20 p. 7 pls.

1926. The diaspine Coccidae of Japan IV. Genera *Cryptoparlatoria, Howardia, Sasakiaspis, Diaspis, Aulacaspis, Pinnaspis*, and *Prontaspis*. Dept. Finance, Japan Imperial Plant Quar. Service. Rev. Bur. Tech. Bul. 4, 44 pp. 12 pls. (1 colored.)

1927. A new species of the genus *Fiorina* from Japan. Annot. Zool. Japanenses. vol. 11 p. 151–154, 1 pl.

—— A list of Coccidae (scale insects) known from China. Lingnaam Agr. Rev. vol. 4 p. 70–72.

1928. The diaspine Coccidae of Japan V. Genera *Chionaspis*, *Tsukukiaspis*, *Leucaspis*, and *Nikkoaspis*. Min. Agr. & Forestry, Japan. Dept. Agr. Sci. Bul. 1, 39 p. 9 pls.

1931. The diaspine Coccidae of Japan VII. Genus *Phenacaspis*. Min. Agr. & Forestry, Japan. Dept. Agr. Sci. Bul. 2, 14 p. 3 pls.

—— The genus Kermes of Japan. Min. Agr. & Forestry, Japan. Dept. Agr. 29 p., pls. iv–xi (1 colored.)

—— On the genus Kermes in Eastern Asia. Ronytu, vol. 5 p. 47–51.

1932. Two new conifer-infesting scale insects from Japan. Philippine Jour. Sci. vol. 48 no. 1, p. 51–55. 3 figs.

—— The genus *Aclerda* in Japan, including Formosa. Min. Agr. & Forestry, Japan. Dept. Agr. p. 57–67, 4 figs.

1933. 1. The diaspine Coccidae of Japan, VII. II. Key to genera of Diaspinae in Japan. III. An index to species of coccids recorded in the diaspine Coccidae of Japan, I–VII. Ministry of Agr. and Forestry, Japan. Dept. Agr., Sci., Bul. 3, 51 p. 11 pls.

(This "treatise is the last and posthumous report of his studies concerning Japanese Diaspine Coccidae by the late Mr. Inokichi Kuwana, and completes his studies of Diaspinae.")

MALLOPHAGA

1902. Mallophaga from the Galapagos Islands (With Vernon L. Kellogg). Proc. Washington Acad. Sci. vol. 4 p. 457–499.

ALEYRODIDAE

1909. Aleyrodidae of Japan (In Japanese). Insect World. vol. 13 no. 1 p. 2–6; no. 10 p. 9–11; vol. 4 no. 1 p. 13–15.

1910. Aleyrodidae of Japan (In Japanese). Insect World. vol. 4 no. 2 p. 8–9; no. 3 p. 7–8.

1911. White flies of Japan. P. C. Jour. Ent. & Zool. vol. 3 p. 620–627, figs. 207–208.

1927. On the genus *Bemisia* found in Japan. Annot. Zool. Japanenses. vol. 2 p. 245–252.

1928. Aleyrodidae or white flies attacking citrus plants in Japan. Min. Agr. & Forestry, Japan. Dept. Agr. Sci. Bul. 1 p. 41–78, pl. x.

APHIDIDAE

1918. Some Japanese Aphididae (with E. O. Essig). Proc. Calif. Acad. Sci. (4) Zool. vol. 8, no. 3 p. 35–112, 40 figs.

GENERAL

He is one of the authors of the splendid new book on Japanese insects entitled "Nippon Konchu Zukan. Iconographia Insectorum Japanicorum. Hokuryukan, Tokyo, 1932. In Japanese. It contains more than 2400 pages and illustrations of more than 4000 species of insects. (Reviewed in Jour. Econ. Ent., vol. 25, pp. 1117–1118, 1932.)

E. O. ESSIG

Current Notes

Z. P. Metcalf, Professor of Zoology and Entomology, State College of Agriculture and Engineering of the University of North Carolina and Entomologist of the Agricultural Experiment Station has been appointed a member of the Administrative Council of the University by President Graham

Mr. Lee A Strong, who for the past four years has been Chief of the Bureau of Plant Quarantine, became Chief of the Bureau of Entomology, October 1, 1933, succeeding Dr Marlatt who retired on September 30 Mr Strong was formerly Assistant Director of Agriculture in California and served also as a specialist in plant quarantine in the U S Dept of Agriculture before becoming Chief of the Bureau of Plant Quarantine Avery S Hoyt, formerly Assistant Chief of the Bureau of Plant Quarantine is acting Chief

"A Summary of Recent Results with Pyrethrum as an Agricultural Dust" This is an eight-page multigraphed memorandum dated September 1933, issued by John Powell & Company, of 114 East 32nd St, New York City Although their names do not appear, it was compiled by Drs Alfred Weed and M D Leonard, Research Entomologists for this company A resume of a considerable amount of reliable experimental data is contained in this "Summary" and entomologists who are interested may obtain a copy by writing direct to the New York Office

Mr J N Knull formerly Assistant Entomologist and Specialist in Entomology, Bureau of Plant Industry, Penna Dept of Agriculture and recently Research Entomologist with the Mount Alto Forestry School has been appointed Curator of Insects and Assistant Professor of Entomology in the Dept of Zoology and Entomology, Ohio State University, effective January 1, 1934 He will have charge of the arrangement and care of the Osborn collection of Homoptera the Wenzel collection of Coleoptera, the Tallant collection of Lepidoptera, and the University collection.

Dr Charles L Marlatt, who reached his seventieth birthday on September 26, retired September 30, 1933, as Chief of the Bureau of Entomology, U S Department of Agriculture Before coming to the Department, in 1889, Dr Marlatt was assistant professor of entomology and horticulture at the Kansas State Agricultural College, where he had received B S (1884), M S and D Sc degrees Dr Marlatt soon became associated with the administrative work of the Bureau of Entomology and served as assistant chief from 1894 to 1927 During that period he made important contributions to the information on the life-history, habits, and methods of controlling important plant pests, particularly the forms that attack fruit trees and cereal and forage crops, and stored-product and household insect pests He also conducted technical studies on the classification of insects Dr Marlatt is probably best known for his work which led to the passage of the Plant Quarantine Act of 1912 On the evening of his 70th birthday, September 26 1933, he was given a farewell dinner at the Cosmos Club by his associates and friends in the Department Upon his retirement, September 30, he was presented with a watch, suitably inscribed, by his associates in the Bureau.

Horticultural Inspection Notes

In a recent issue of the "Boll. della Soc. Ent. Italiana," an earlier report that the San Jose scale had been found in Italy, is denied bv Trinchieri.

The Territory of Puerto Rico has established terminal inspection of parcel post shipments of plants and plant products under the provisions of the act of March 4, 1915 (Sec. 596, Postal Laws and Regulations). The inspection service is maintained at San Juan only.

On November 4 the Bureau of Plant Quarantine of the United States Department of Agriculture at Washington, D. C., moved from the Lemon Building at 1729 New York Ave., to Building "C", at 7th & B Sts., S. W. This is the same building in which most of the divisions of the Bureau of Entomology are located.

According to an announcement in a recent railway circular, a quarantine relating to strawberry yellows was placed by the Director of the Oregon State Department of Agriculture on July 10, requiring certification of strawberry plants transported from Josephine Co., Ore., to any other part of the State.

The State of Louisiana placed rules on October 15, requiring State nursery inspection of cut flowers shipped into or within the State, for the reason that "cut flowers * * * are responsible for the dissemination of insect pests and plant diseases * * *." Inspection is required of "the immediate premises and plants on which the cut flowers were grown."

The Eastern Plant Board met at Philadelphia on November 22, immediately preceding the meeting of the Eastern States Entomologists on the two following days. Among the important subjects discussed were the Dutch elm disease outbreak in New Jersey and New York, and various Federal plant quarantine and insect suppression projects, including the gypsy moth and Japanese beetle problems.

Scrubbing, immersing or spraying with an insecticide containing 2 per cent of oil is the treatment for citrus stock which the Florida State Plant Board now requires of nurserymen in that State, under an amendment of Rule 8-E placed on September 18 Formerly the stock was required to be scrubbed in a fish-oil solution, before being shipped. Rule 8-C, which prohibited the movement of undefoliated citrus stock except under certain conditions was repealed on the above date.

On October 25 the Department of Agriculture held a conference at Washington, D. C., to re-examine the underlying principles involved in the interpretation and enforcement of the Nursery Stock, Plant, and Seed Quarantine No. 37. The hearing was well attended and various points of view were expressed by the different interests represented, which included commercial nurserymen, garden clubs, florists, bulb growers, citrus growers, plant quarantine officers, and others.

A special quarantine to prevent the further introduction of the Dutch elm disease into the United States was issued on October 21, 1933. Under the provisions of this quarantine and of Circular BPQ-356, which gives detailed information concerning it, the entry of elm burl logs into the United States is permitted on condition that the logs are free from bark and from wood-burrowing insects, and on condition that the logs are treated at a temperature of 180° F. or over for at least two hours.

A conference at which plant quarantine officers, phytopathologists, foresters, and others, discussed the problems arising from the New Jersey and New York outbreak of the Dutch elm disease was held at Washington on October 26. At that conference, Mr. R. Kent Beattie, representing the Bureau of Plant Industry, stated that the number of trees found infected this season up to that time was 603 in New Jersey, 46 in New York, one in Connecticut, one in Maryland, and one in Ohio, a total of 652. The safeguards employed by the State of New Jersey to keep infected trees from being shipped outside the infected areas, were described by representatives of the New Jersey State Department of Agriculture.

The October issue of the International Bulletin of Plant Protection published at Rome, reports the finding of the Colorado potato beetle in England. Three specimens were found, only one of which was alive, not far from the mouth of the Thames River. All field crops of potatoes within 16 kilometres of Tilbury in Essex, and within 8 kilometres of Gravesend in Kent were sprayed by the government with an arsenical wash and the soil of the allotment in which the beetles were discovered was fumigated. The treatment will be repeated during the autumn.

Recent developments in the phony peach disease situation include the revocation or modification of Illinois and Arkansas regulations, the problem to be handled in the former State without the use of quarantine measures and in the latter by special inquiry as to satisfactory inspection and proper sanitation measures before shipping permits are issued to nurserymen in the infected State. The States of Alabama and Louisiana have placed regulations relating to interstate and intrastate movement. In the case of Alabama certification is based on (1) a disease free county, or (2) mile-radius inspection or (3) culling to eliminate borer infested trees. In Louisiana the destruction of all infected trees in the State is required and certification for shipping is based on conditions similar to (2) and (3) above.

According to a statement presented by Mr. L. H. Worthley at a hearing to consider the extension of the Japanese beetle quarantine to the states of Maine and West Virginia on October 24, a few beetles were captured at each of a large number of different points south and west of the regulated areas this past summer. The only localities at which ten or more such beetles were found outside the regulated areas were Portland and Waterville, Maine, Berwyn, Bethesda, Bladensburg, Chevy Chase, Hyattsville, Riverdale, and Silver Springs, Maryland, Salamanca, New York; Erie, Pennsylvania, and Keyser, West Virginia. In the case of other points, it is considered by the department that the evidence does not necessarily indicate an established infestation.

A public hearing was held at Memphis, Tenn., on November 20, at which consideration was given to the extension of the pink bollworm quarantine regulations to the State of Georgia. Extension of the quarantined area in Florida and Texas was also discussed. The Georgia reports involve only about eleven specimens found in gin trash and in a field near the line between Berrien and Tift counties. The Texas discoveries consist of the taking of a small number of specimens at a number of points in Hockley, Terry, Dawson, and Gaines counties, and in gin trash from cotton grown in Lea County, New Mexico. The Gaines County area was brought under quarantine in an amendment issued on October 24. In announcing the hearing, the Department stated that it did not consider the situation in either the Georgia Florida dis-

trict or the Texas-New Mexico area with undue alarm, owing to the lightness of the infestations and the fact that similar infestations in the past have yielded to eradication measures.

Practically all the agricultural laws of California formerly in effect were revised or revoked under the new Agricultural Code adopted at the last session of the legislature. A broad definition of "pests" written into the law, has the effect, we are info med, of placing weed seed under quarantine control, "so that prevention of the introduction of noxious weeds is now as much a part of the duties of [California] quarantine inspectors as the prevention of the introduction of injurious plant diseases and insects." Some of the old laws which were repealed related to date-palm scales, walnut codling moth, and the regulation of transportation of grapevines for fuel. Retained in the new law are the provisions for inspection of incoming shipments of nursery stock at destination and for proper disposition when there is "reasonable cause to presume" that it may be infested or infected. All plant quarantine regulations involving another State are subject to approval of the Governor.

Under a recent amendment to the Wisconsin nursery inspection law, a reciprocity fee of $10 may be charged out-of-State nurserymen, according to the Florists' Review of September 14. Until recently Wisconsin has not charged out-of-State nurserymen for doing business "but with the continual increase in the number of States requiring a dealer's license fee for Wisconsin nurserymen," the Florists' Review statement reads, "It seemed advisable to try to check this by a reciprocity fee which would make it possible to charge other States a license fee when they charge Wisconsin nurserymen for such a purpose." Provision is made in the amendment for the commissioners of the Wisconsin State Department of Agriculture and Markets to enter into reciprocal agreements with officers of other States "under which nursery stock owned by nurserymen or dealers of such States may be sold or delivered in this State without the payment of a Wisconsin registration fee, provided like privileges are accorded to Wisconsin nurserymen or dealers in such other States* * *.

Prof. A. E. Stene, Chief, Bureau of Entomology and Plant Pest Control of Rhode Island, sends the following statement as to the growth of nurseries and nursery inspection in the State: "Twenty-nine years ago, there were only twenty nurseries and none contained over ten acres. The total area of nurseries perhaps did not amount to much over 60 or 75 acres. According to our records for last year there are now 76 nurseries, 2,994 acres in property and 823 acres in stock, 137,365 square feet of greenhouses, nearly 81,000 square feet of hot bed sash and 1,250,000 square feet in propagating beds. Three nurseries contain over 100 acres and one over 200 acres. The value of this business in 1904 would probably have amounted to not over $60,000 or $70,000. 1931 which was a better test of the status of the business in Rhode Island than 1932 gave us a total estimated value of over $750,000. It is needless to say that where one man was able to readily do the work in the time available in 1904, it now takes a considerably larger number of workers."

The Rhode Island State Department of Agriculture is planning a special inspection during the winter and spring to determine whether there are any infestations of the European pine shoot moth. None were found in the ordinary course of inspection during the middle of the summer, but a more careful survey of the plantings is believed desirable in view of the rather heavy outbreak of this insect in Connecticut.

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